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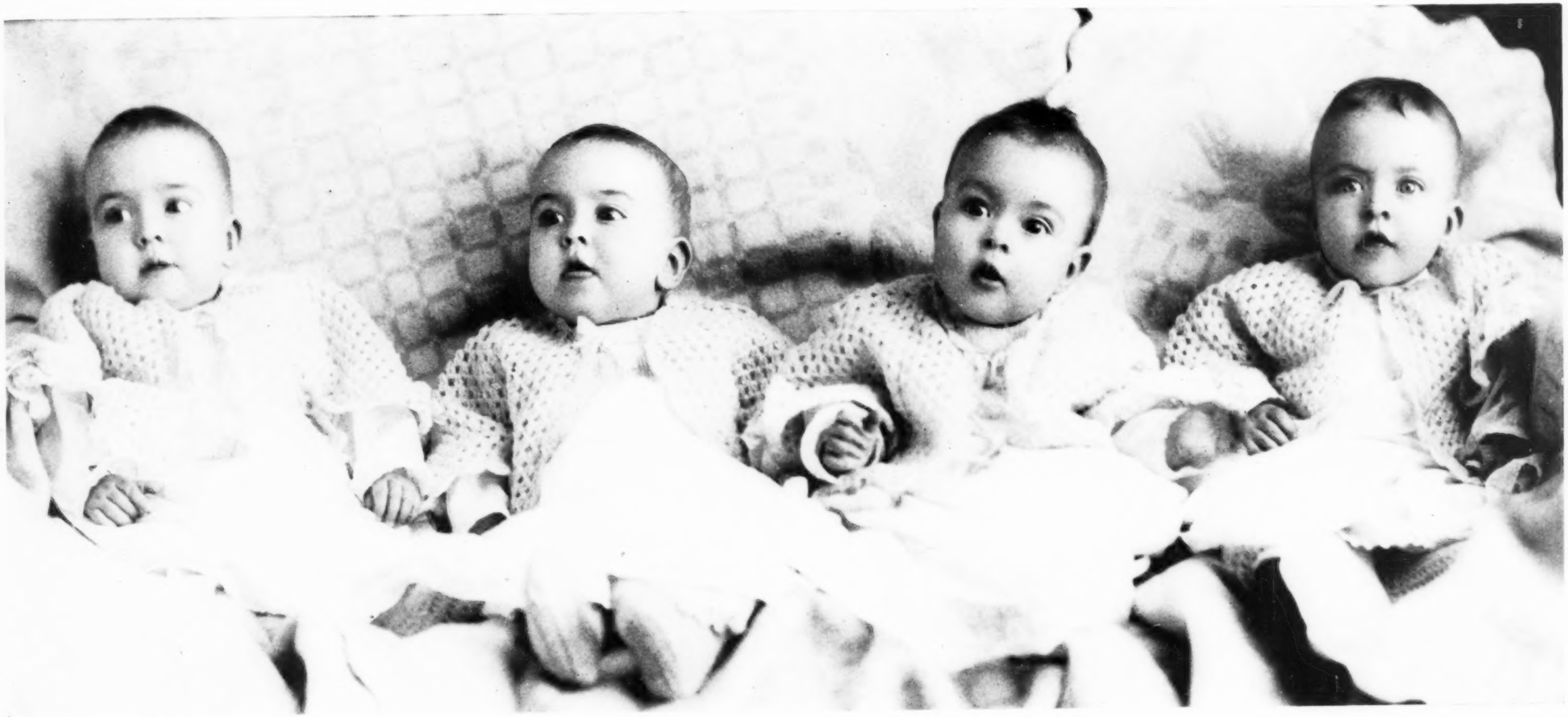

FOUR BABY GIRLS AT ONCE

These quadruplet daughters were born to Mr. and Mrs. F. M. Keys, Hollis, Okla., on July 4, 1915, and were seven months old when the photograph was taken. Their weights at birth were as follows (reading from left to right): Roberta, four pounds; Mona, four and one-half pounds; Mary, four and one-quarter pounds; Leota, three and three-quarter pounds. In the latter part of February, Roberta weighed sixteen pounds, and each of the others weighed sixteen and one-quarter; they have never had any other nourishment than their mother's milk. Their aunt vouches for the fact that the care of the four is less trouble than a single baby often makes. The mother has had no previous plural births, although she has borne four children prior to these. Her own mother had but two children, a son and daughter, and there is no record of twins on the mother's side. The father of the quadruplets is one of twelve children, among whom is one pair of twins. In so far, therefore, as heredity is a cause, it is possible that the appearance of these quadruplets is due to the influence of the father, not the mother. Such a supposition requires that the girls should all have come from one ovum. The question of the part which heredity plays in plural births is not yet cleared up, and its study may throw light on other problems of heredity. In this case note the uniform shape of the mouth, and the ears, set unusually low on the head. Photograph copyrighted. (Frontispiece.)

IS TWINNING HEREDITARY?

Problem Much More Complicated Than It Appears at First Sight—Two Kinds of Twins—Possible Influence of the Father—The Frequency of Multiple Births

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THE layman is often impatient with the indefinite character of much of our eugenic information. It is not easy for him to understand the difficulties that attend an investigation into the heredity of what may seem to be a single clear cut characteristic. For this reason it may be of interest to point out a few of the obstacles met in such a study. The question of a possible hereditary tendency for twin production may be selected for this purpose. The problems encountered are not identical with those that would be met in the investigation of the heredity of some other characteristic but they are in a measure similar and will serve to furnish a typical example.

The occasional occurrence of twins among the offspring of man and other animals that usually produce only one offspring at a time, has always been a matter of interest to both the popular and the scientific mind. This interest is due not so much to the fact that these mammals may sometimes produce two or more young at a birth as to the extreme similarity that frequently exists between the young thus produced. The causes that result in twin production, however, are not fully understood, and still less is known of the rôle heredity plays in this connection.

If one attempts to learn more about the heredity of twinning he is forced to consider a number of subsidiary questions which are in themselves of considerable interest. It is the main purpose of this paper to call attention to the bearing of some of these secondary considerations in relation to the question of an hereditary tendency toward twin production. Incidentally a few fragmentary data from family histories are also presented, but the writer is still collecting this material[1] and has little hope that it will be in shape for final publication for some time.

THE ORIGIN OF TWINS

One of the first questions to be raised at the beginning of an investigation into the existence or non-existence of any hereditary tendency is: What is the exact nature of the characteristic in which this tendency is to be sought? It might seem that nothing could present less difficulty in this connection than twinning. But such is far from being the case.

In the first place, it may be recalled, embryologists hold that twins arise in two very different ways. In one case, two separate egg cells, from the same ovary or from opposite ovaries, are fertilized each by a separate sperm cell. The resulting embryos develop independently like the different members of an ordinary litter. They need have no greater resemblance to each other than brothers and sisters born at different times, and the chance that they will be of like sex is the same as for any two consecutive children in the same family. Such twins are variously designated as *fraternal*, *heterologous*, *biovular*. There seems to be ample evidence that many pairs are of this sort.

In the case of the other class of twins, it is claimed that both members of the pair are derived from a single egg that has been fertilized by a single sperm. At some time subsequent to fertilization two centers of growth appear in the

[1] The writer of this paper will welcome family histories in which several pairs of twins occur, or other data bearing on the question of hereditary twinning.

DO THESE GIRLS LOOK ALIKE TO YOU?

These triplets from St. Louis illustrate one of the difficult problems that confronts the student of hereditary twinning. Triplets, it is believed, may be derived from one, two or three egg cells. In which class do these three girls belong? People who see them for the first time usually consider them very similar. Their eyes, hair and complexions are practically indistinguishable to ordinary observation. They are the youngest of thirteen children, and their hair is darker than that of any of their brothers or sisters. Yet it will be seen that their features are by no means identical, although more similar than one would expect if they really represent three distinct ova. The doctor who attended their birth says they had each a complete and separate set of foetal membranes. There are no other cases of twins or triplets known in this family, or among the immediate relatives in Germany. (Fig. 1.)

embryonic cell-mass and from each of these centers a distinct individual develops. Such twins, known as *identical*, *homologous*, or *uniovular*, are always of the same sex and, moreover, often show the most striking similarity.[2] The evidence in favor of the existence of this type of twins is drawn from many sources and seems quite conclusive.[3]

It will be apparent from the foregoing that there are at least two fundamentally different classes of twins which must be taken into account in a study of heredity. Biovular twins, since they owe their existence to the simultaneous ovulation of two ova instead of one, must be explained entirely by reference to some attribute of the mother and could not possibly be due to any characteristic of the father. Uniovular twins, on the other hand, might conceivably be due to factors supplied by either the father or the mother or, like a recessive character, to some inherent peculiarity in the germ cells of both parents. In one case the characteristic is manifested in the parental generation (mother), in the other it appears in the filial generation (twins themselves). This is an obvious and important distinction. Indeed it might be argued that the occurrence of uniovular and biovular twins represents two entirely distinct and unrelated phenomena. Yet this point is frequently neglected in studying twins from a statistical or hereditary standpoint.

Simon Newcomb's memoir[4] "A statistical Inquiry into the Probability of Causes of the Production of Sex in Human Offspring," may be mentioned as one illustration of such an oversight. In this article it is shown from very extensive data that twins are of the same sex much more frequently than can be explained by reference to the laws of chance. Even so careful a student as Professor Newcomb, proceeding from this fact and completely ignoring the possibility of the existence of these two types of twins, tried to prove that the sex of twins, and therefore all embryos, is determined subsequent to fertilization. If, however, the current views as outlines above are correct it follows that, while the data presented by Newcomb are exactly what would be expected, his arguments from them are practically pointless.

THE TWO KINDS OF TWINS

Since embryologists insist that students of heredity recognize the existence of these two classes of twins, the next question that arises is as to how they may be distinguished. It is commonly assumed that twins of opposite sex are necessarily biovular, while those of similar sex may belong in either class. It therefore becomes a question of passing judgment on the degree of resemblance between the members of each pair where the sex is the same. This is no easy matter. On the one hand biovular twins may sometimes closely resemble each other as is shown by the fact that two brothers or sisters born several years apart are frequently very similar. That uniovular twins, on the other hand, may be very different is strikingly indicated by those cases in which one of the individuals has suffered from some handicap before birth, or is reduced to a mere parasite attached to its more vigorous partner. Identity is rarely attained.

The relation of the foetal membranes in which the twins develop has been proposed as a criterion, and it is probably true that any pair of twins which at birth are found to be surrounded by a single set of membranes have come from a single ovum. But it does not necessarily follow that those surrounded by separate sets of membranes are biovular.[5] That they frequently are not

[2] The extent of this similarity, which may reach even to the finger prints, has been studied by Professor Wilder and others: see H. H. Wilder in the *American Journal of Anatomy*, vol. i.

[3] The following observations may be mentioned: (a) in some lower forms it is possible experimentally to cause two embryos to develop from one egg; (b) in the case of the North American Armadillo, it is definitely established that *four* young regularly develop from each egg; (c) embryos showing all grades of division from a slight bifurcation to complete separation of individuals are actually found.

[4] Carnegie Institute of Washington Publication No. 33.

[5] This is the present view of Sobotta and others, but such data as are referred to in the text seem to throw some doubt upon it.

PLURAL BIRTHS ARE NOT AN UNMIXED BLESSING

"The stork is one bird that does not go South with the millionaires in winter, but remains up North conscientiously on the job," says Charles Hopper, of 1620 Race Street, Cincinnati, Ohio. Thus Hopper, in announcing the birth of triplets, announces at the same time a cheerful outlook on life. His three latest daughters, who were just a week old when the photograph was taken, are here shown in the arms of their grandmother, Mrs. Elizabeth Koch. The Hopper home is no strange place to the stork, who has made seven previous visits. This is the first time he has ever been so generous in any one call, however, all of the other children having been born singly. Photograph from Paul Thompson. (Fig. 2.)

so is suggested by the following reasoning.

It is found,[6] for example, that of 37,621 pairs of twins born in Germany and France, there were 13,315 cases in which one twin was a boy, the other a girl. Now an interpretation that may be put on such data is this: These 13,315 cases represent half of the biovular twins—since such twins have equal chances of being of the same or of opposite sex. This means that of the whole number roughly 26,630 cases represent biovular twins and the remaining 10,991 cases represent uniovular twins, from which it appears that 29+ % of all twin cases are uniovular.[7] The textbooks of obstetrics published in Germany and France, basing their statement on the relations of foetal membranes, generally give the number of uniovular twins as about 15%. Here is a discrepancy that seems to have been generally overlooked, but it is very probable that the difference between 15% and 29% represents the number of cases in which uniovular twins develop in separate sets of foetal membranes.

POSSIBILITY OF OTHER KINDS

There is another point that cannot well be overlooked in this connection. Prof. Thorndike[8] found that when the degree of similarity between the two members of different pairs of twins is measured and plotted for a large number of cases the resulting curve is smooth and not two-humped as might have been expected. The mode falls at a point higher than that for comparisons between ordinary brothers and sisters, but considerably below the point representing identity. If twins fall only into the two classes usually postulated it is difficult to see how such a result could be obtained. Similar study of other, and if possible, more extensive material is greatly needed.

It may ultimately be possible to show that Thorndike's smooth curve represents the leveling effect of like environment reacting on biovular twins and of somatic variation affecting uniovular twins, but it may also be that the two types mentioned do not represent all the classes of twins, for it must be admitted that theoretically there are other possibilities. One such possibility is suggested by the work of Boveri[9] and others on the eggs of bees and sea-urchins. It was found by these investigators that the entrance of the sperm to the egg *occasionally* stimulates a precocious division of the latter so that the sperm nucleus is able to unite with only one half of the original egg nucleus, leaving the other half to develop (in these lower forms) parthenogenetically. If such a condition were to arise in man, the second half of the egg nucleus might, so far as is known, be fertilized by one of the innumerable superfluous sperm cells, in which case we would perhaps get a pair of twins derived from one egg and two sperms. Such three-germ twins might even be of opposite sex, yet they should be more similar than ordinary brothers and sisters. The at present puzzling distribution of twins in certain families could be explained very well on this assumption, but such a postulate lacks proof, and one must proceed cautiously in introducing new hypotheses.

FREQUENCY OF TWINS

For the student of heredity it is always desirable to know the "normal incidence" of the character under investigation. Knowing this it is possible to calculate, on the assumption that the characteristic appears fortuitously, the probability that it will be found once, twice or oftener in groups of a given size. With this information at hand one may then determine whether the characteristic regularly appears in certain families enough oftener than the laws of chance would explain to warrant regarding it as hereditary.

The approximate incidence of twin births as a whole is easily obtained.

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[6] Simon Newcomb, *op. cit.*

[7] Miss Margaret V. Cobb has recently applied the same reasoning to American data with similar results. *Science*, N. S., Vol. XLI, No. 1057, pp. 501, 502. April 2, 1915.

[8] *Archives of Philosophy, Psychology and Scientific Methods*, No. 1, 1905.

[9] This work is scattered through numerous journals dealing with experimental embryology, etc.

TWINS FROM TWO DISTINCT EGG CELLS

As they are of different sexes, it is probable that they are not from the same egg cell; and the difference in their appearance, at first sight, is considerable. But closer examination shows that the hair is the only visible feature in which they differ widely. Photograph from The Nursery Studio, Washington, D. C. (Fig. 3.)

For example, it is stated[10] that in Prussia one birth in eighty-nine results in twins; in Naples, one in 158; in Russia, one in thirty-two, etc. In certain provinces of China twins are said to be almost unknown. Of the 75,030 births recorded in St. Louis during the five years from February, 1910, to February, 1915, 828 are reported as twins or triplets. This indicates that the incidence of multiple births here is about one to 90.6. Of course these figures tell nothing of the relative frequency of the different classes

[10] Textbooks of obstetrics, etc. The Prussian statistics are said to be based on 13,000,000 births, the Russian on 6,000,000.

FROM ONE OR TWO EGG CELLS?

The most obvious difference between these twins is that one drinks faster than the other. In features the resemblance is close. Yet no one can say from mere inspection whether they represent the twinning that is due to the fertilization of two egg cells, or the twinning that is due to a single egg cell splitting in halves; and as the two kinds of twinning are very likely inherited in a different manner, the study of the problem is made difficult. Photograph from the Nursery Studio, Washington, D. C. (Fig. 4.)

of twins, a decided handicap for the student of heredity.

THE HEREDITARY TENDENCY

The kind of evidence that one gets as to the heredity of twinning may be indicated by reference to a group of fifty St. Louis families. The investigator had no knowledge of any of these families until in each case, the birth of twins was reported to the bureau of vital statistics. On looking into the family histories, it was learned that these fifty new-born pairs of twins had 171 older brothers and sisters born singly and twenty (ten pairs) who were twins. The frequency of twins among the brothers and sisters of twins then is about 1:18. In the mothers' fraternities there had been 318 single births and ten pairs of twins (1:32), and in the fathers', 219 single and eight pairs of twins (1:37). Comparing these figures with the "normal incidence" for St. Louis (1:90.6) one is justified, especially since essentially similar figures are obtained from more extensive data, in concluding that twin production is frequently a family peculiarity.

Analyzing the individual families, evidence is found that what seems to be biovular twinning is hereditary in the direct female line. The tendency to uniovular twinning likewise seems to be transmitted through the female and, since the incidence of twins is higher than normal in the fraternities of the fathers of twins,[11] it is probable that it may also be transmitted through the male. Whether there is any relation at all between the two types is an open question.

While some of these families furnish beautiful charts indicative of an hered-

[11] There is indication that this is also the case with Shropshire sheep. See Rietz and Roberts, *Journal of Agricultural Research*, September, 1915.

itary tendency for twinning, others are frequently met with in which, while there may be a record of many individuals in several generations, only one pair of twins appears. In these instances the twins sometimes seem to be biovular, sometimes uniovular. Such family histories may indicate that while twinning is in some way hereditary in most instances, it may nevertheless at times appear sporadically. The most probable inference to be drawn from this fact would seem to be that the ability to produce twins is possibly common to all strains and that the frequency of twin births in different lines is merely relative. It is not likely, on the one hand, that strains will be found in which twins never occur nor, on the other hand, in which there is nothing but twins. But that such causes as may tend toward twin production[12] are more constant or react more effectually in some lines than in others seems evident. That one of the factors commonly involved in the case of both uniovular and biovular twinning is hereditary seems to be well established, although it cannot as yet be stated whether or not the method of transmission is Mendelian.

SOLUTION NOT IMPOSSIBLE

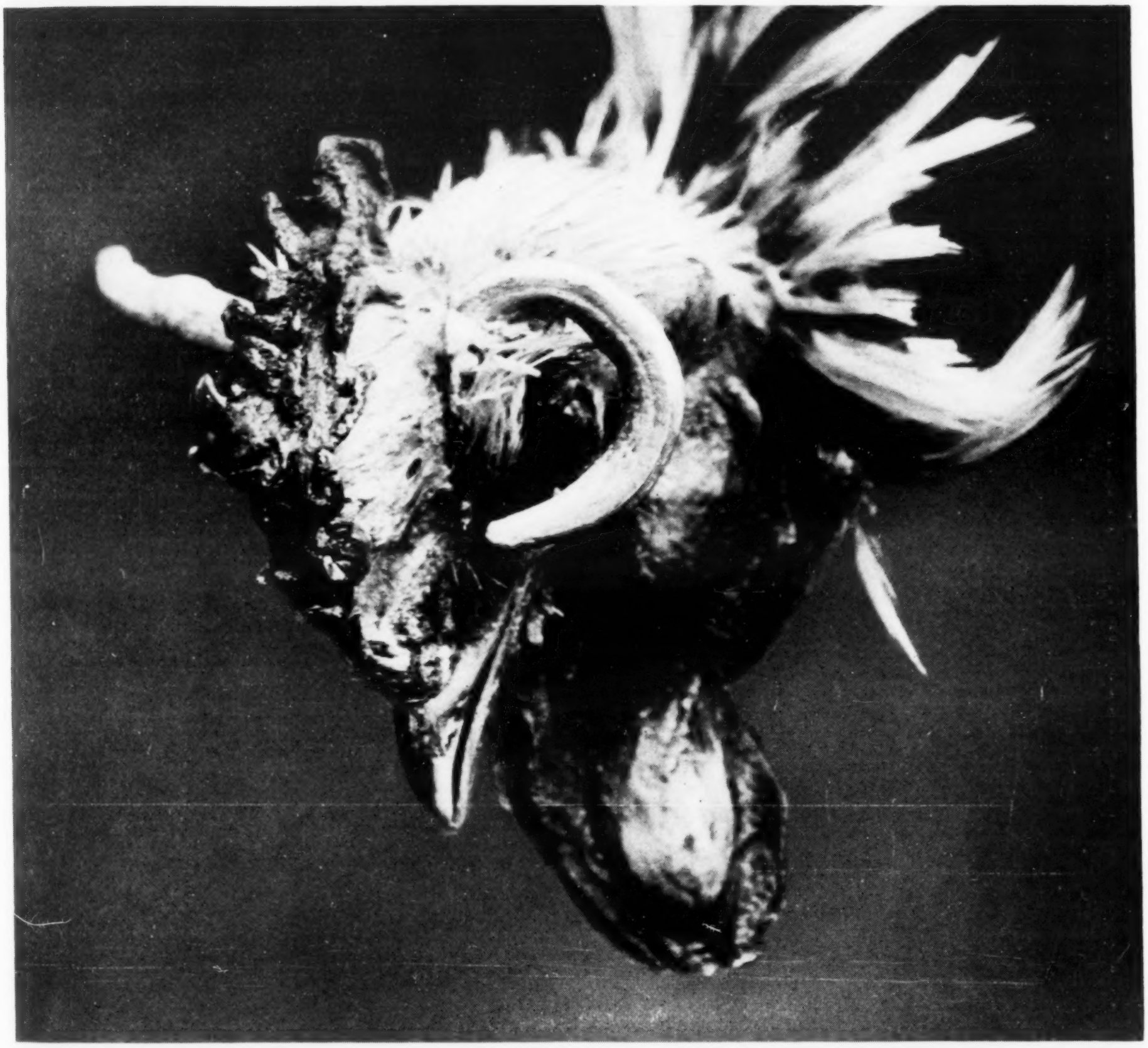
In the foregoing discussion an attempt is made to give the "setting" of a concrete problem in the study of human heredity for which purpose the question of twinning is selected. The obstacles that are met in attempting to solve this problem are found to be of such a nature as to prevent a quick arrival at final conclusions, but they are not such as to discourage the hope that a definite solution of the problem may be obtained. Before such a solution is reached, however, a number of incidental, and perhaps unforeseen, questions must be disposed of. These questions often call for excursions into somewhat remote fields of investigation, but this fact instead of detracting from the interest of the study or the urgency for its prosecution, adds materially to both. It is only through the careful evaluation and correlation of all these contributary data that entirely satisfactory conclusions can be hoped for.

[12] There is not space to discuss these causes in detail. Many obstetricians consider age an important influencing factor (biovular twins). A slight transient hyper-acidity of the uterine fluids has been suggested as a factor favoring the production of uniovular twins.

Laws to Restrict Miscegenation

Twenty-eight states have laws or constitutional provisions forbidding the intermarriage of negroes and white persons, while twenty States have no laws on the subject, according to Albert Ernest Jenks, who reviews the legislation in the *American Journal of Sociology* (March, 1916). In ten States, bills introduced in the legislatures and aimed at forbidding negro and white marriages were defeated in 1913, largely through the activity of the National Association for the Advancement of Colored People. This association announces that it does not favor intermarriage, but objects to such legislation on the ground that it is ineffective and discriminatory, that it leads to the degradation of negro women, and "for the physical reason that to prohibit such intermarriage would be publicly to acknowledge that black blood is a physical taint, something no self-respecting colored man and woman can be asked to admit." Prof. Jenks points out that in the States which have laws, these laws differ widely in the interpretation placed on the word "negro." "If effectual legal barriers against negro-white amalgamation are desirable," he concludes, "they should perfectly agree as to the legal and racial status of the so-called 'negro,' and miscegenation of every form and every instance between negro and white persons must be made a felony in every American State."

A FOWL WITH HORNS



Here is a Wyandotte cock with well-developed horns on each side of the head. They are similar in character to the spurs which regularly grew on males of the domestic fowl, and are attached to the skin only, having no connection with the skull. The horns are about 1 inch in circumference at the base; the straighter one is 2 inches long and the curved one 3 inches long.

The bird was raised by Dominic Lynch of 1934 Ruan Street, Philadelphia, Pa., and killed last Thanksgiving. The head came into the possession of Charles H. McLaughlin, 1500 North Alden Street, Philadelphia, who brought it to the office of the JOURNAL OF HEREDITY, and furnished the data about it. He had it mounted by David N. McCadden, of the Academy of Natural Sciences, Philadelphia.

From the point of view of development, these horns are merely modified feathers, which in turn are, like the cock's spurs, merely modified scales of the skin. It is difficult to explain why these spurs should have appeared on the bird's head, but there seems to be no reason why they should not do so. On the other hand, it is conceivable that such horns might be produced artificially by grafting spur tissue on the fowl's head when it was young. Mr. McLaughlin asserts that these horns are wholly a natural growth. The taxidermist who mounted the head writes that they appeared to be a natural growth, consisting merely of modified feathers. Such a growth is to be considered merely a freak, and probably would not be inherited. (Fig. 5.)

WHAT THEY SAY ABOUT INBREEDING IN EUROPE

INBREEDING has come during the last few years to be recognized in Europe as one of the most valuable instruments of the live stock breeder. So says Chr. Wriedt, who has spent the winter in the United States as a representative of the Norwegian department of agriculture, studying the position of breeding and genetics here.

Mr. Wriedt notes that, apart from the professional geneticists and a few great breeders, those concerned with live stock in the United States still display a good deal of suspicion and misunderstanding of the use of inbreeding and linebreeding. European breeders, too, used to be skeptical. Their attitude was influenced largely by the authority of the German scientist, Settegast, who dominated the field of live stock breeding half a century ago, and who denounced consanguineous breeding in every form.

"The first impartial investigation," says Mr. Wriedt, "was started by Count Georg Lehndorff, who was in charge of the governmental horse-breeding operations in Prussia for a generation, and exercised a great influence for good on the art of breeding. Through studies of the pedigrees and progeny of thoroughbred horses, he came to the conclusion that moderate inbreeding[1] was largely responsible for the best records; and his publications, beginning about 1880, mark the commencement of the new school of breeding in Germany.

"But the turning point, in Germany, is the publication in 1909 of A. de Chapeaurouge's great book on inbreeding, in which he analysed the pedigrees of English thoroughbreds, Anglo-Norman trotters in France, and the best private studs of East Prussia. He was in many ways a pupil of the Australian, Bruce Low. The greatest defect of de Chapeaurouge is that he was born too soon to be a good geneticist—he is quite out of sympathy with the Mendelian movement.

"His work was based wholly on practical breeding; on the analysis of actual pedigrees. It really led to the foundation of a whole school of breeding on the continent, and to the foundation of the German Genetic Association,[2] a powerful organization which has worked incessantly to promote intelligent breeding.

PEDIGREE-STUDY EMPHASIZED

"The guiding spirits of this association are two able men, Dr. Felix Hoesch, the president, a breeder of Belgian horses and swine, and Dr. Georg Wilsdorf, the secretary, who is in charge of live-stock breeding in the province of Brandenburg. These men combine to an unusual degree the viewpoints of the practical breeder and the geneticist, and under their leadership the German Genetic Association has published a series of valuable yearbooks, fifteen monographs on various breeds, and a score of bulletins on topics in scientific breeding, particularly as related to the study of pedigrees. Pedigree-study is, in fact, the keynote of the association's activity, and the interest which the breeders take in it may be judged from the fact that Wilsdorf's 'Pocket Pedigree Book' for the black and white cattle, a breed corresponding to the Holstein-Friesians, is now in its fourth edition."

"And what do they learn from all this pedigree study?"

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[1] In other words, what we call line-breeding. Much of the so-called inbreeding in Europe is not of a close character, and in the United States would never be called inbreeding, but merely line-breeding. The difference, of course, is merely one of degree.

[2] Deutsche Gesellschaft für Züchtungskunde. Its headquarters are in Berlin, and it is said to have 3,400 members.

"In general," Mr. Wriedt said, "They learn this: that in every breed the valuable strains or families are found to contain the names of a very few ancestors, repeated a great many times. In short, that the valuable part of any breed is due to a small number of animals, usually sires; these sires, which we would call prepotent, have been used as much as possible, through inbreeding and linebreeding.

"The secret of the great successes in live stock breeding, then appears to be merely that the valuable 'blood lines' were picked out and conserved through inbreeding."

"And this inbreeding does not lead to disaster?"

"Not at all, if the animals are good; Take for example the famous Kladrub breed of horses in Bohemia. It is probably the purest breed in the world—one of the few breeds of horses that has any right to call itself pure.

THE KLADRUB BREED

"Its foundation was a Spanish breed of heavy carriage horses which had been closely bred and kept pure for many hundreds of years, when it was taken to Austria in the sixteenth century for the use of the court. The chief characteristics of the breed are the Roman nose, arched neck, heavy crest, great height (17 or 18 hands) and extravagant gait. The breed is a very small one, rarely consisting of more than a hundred individuals, but they are regarded in Austria as the finest parade horses in the world, and may be used only by the royal family and by the Archbishop of Olmütz in Moravia. They are ordinarily seen only on great occasions, when the emperor drives in state behind six or eight of them, all grays or all blacks—the only two colors found in the breed. As they are all for 'show' their trotting speed is only a few miles an hour—this gives them a chance to exhibit their fancy action.

"New blood is very seldom introduced into this breed, and because of the small number of animals existing, inbreeding must have been quite close for several centuries. In recent years no stronger inbreeding than cousin matings has been practiced; yet the Kladrub horses probably represent in their history more inbreeding than any living breed. Are they degenerate? Not a bit. The only unusual result is that it has become very difficult to tell when the mares are in heat. But there has been no diminution in fertility, nor any increase in the number of weak or defective animals. They are very slow to mature, seldom reaching full size before the sixth year; on the other hand, they remain vigorous to a very advanced age.

"This long-continued example of inbreeding shows that if the stock is good at the start, inbreeding will fix the type. It is a pity that these animals are not available for experimental purposes, for according to theory they ought to be extraordinarily prepotent. It would be of great value to find out whether this is actually the case when they are mated with other breeds.

"The Percherons offer a great example of inbreeding and prepotency," Mr. Wriedt continued. "Most of the good animals today trace back in several lines to the two stallions Brillant 755 and Brillant 756.

A GREAT PREPOTENT SIRE

"But the most conspicuous example of prepotency which has ever come under my own observation is that of the Jutland stallion, Aldrup Munkedal, born in Denmark in 1893. He is sire of practically all the sires of that very valuable and by no means inconsiderable breed called the Jutland breed."

"And you believe, I suppose, that inbreeding increases prepotency?"

"Certainly. Prepotency is simply the condition of being purebred—homozygous—for a large number of dominant characters.

"If we understand that prepotency depends on having received the same dominant characters from both lines of descent, we realize that the surest way to produce prepotent animals is by inbreeding, where they are certain to get some, at least, of the same characters from both parents. Occasionally one may get an equally prepotent animal as the result of a cross, but then it is

THE PUREST BREED OF HORSES

One of the few breeds of live stock that can properly be called pure is the Kladrub breed of horses, produced in Bohemia for the use of the Austrian court on state occasions. They have been carefully selected and inbred for centuries, and are now considered by the Austrians to be the finest "show" horse in the world. Only two colors occur, black and light gray. Inbreeding for dozens of generations has done no damage to this breed, despite the widespread popular belief that long-continued inbreeding is certain to be injurious. The carriage of Kaiser Franz Josef is shown, at the recent Eucharistic Congress in Vienna, photographed by Underwood and Underwood. (Fig. 6.)

merely a matter of chance. There is an excellent illustration of this in Hungary, with which you may not be familiar.

"The Nonius breed is one of the most important of Hungarian breeds of general purpose horses. It is founded wholly on one stallion, Nonius, who was produced in France more than a century ago by mating an English halfbred to a Norman mare. In 1815 the Austrians carried him away as one of the prizes of war; he proved to be extraordinarily prepotent, in spite of his mixed ancestry, and is responsible for the existence of the valuable breed which bears his name today."

"And the Europeans are really improving their stock rapidly, by picking out the good blood lines and inbreeding?" I inquired.

"Undoubtedly. In Germany, Austria, Holland and the Scandinavian countries, the movement has made great progress. It had done less in France and Great Britain. In general, I suppose this school of breeding is the strongest, where the publications of the German Genetic Association are best

known. The president of that association, Hoesch, has made a wonderful success in building up the German country swine through moderate inbreeding, based on three prepotent boars."

"Not only is it important to know the good blood lines, but equally to know the bad blood lines. Sometimes a very injurious line of descent is discovered, quite unexpectedly, owing its origin to an animal who perhaps was a first-class performer but not a good breeder. We have one notorious case in a government-owned stallion in Norway, who appears to have been prepotent, but in bad, not good, characters. Every time we find his name in a pedigree, we expect to find unsatisfactory results."

EUROPEANS KNOW THEIR BREEDS

"Do you think that European breeders know their breeds better than Americans do?"

"I fear there can be no doubt about the answer to that question. So far as Germany, Holland, and Scandinavia are concerned, the bulk of the breeders are certainly better acquainted with the blood-lines of their breeds, than are the bulk of American breeders. This development has been rapid—it is largely since the time of de Chapeaurouge, or say the last seven years; for de Chapeaurouge worked seventeen years on pedigrees before he published his great book on inbreeding."

"And your advice to Americans would be——"

"That they study their pedigrees more diligently. The progress they have made—astonishing progress, in many lines—has been due to the isolation of good blood lines and the perpetuation of them,[3] but this has been mostly unconscious. They will go more rapidly and surely if they make certain just what are their best strains, and then use those strains to the limit. They will understand and enjoy their work more if they will study genetics, although I do not pretend that a knowledge of genetics will work any revolution in breeding practice at present."

"Can't we proceed still more rapidly if we import the best animals of Europe?"

"Oh, that is all a mistake!" Mr. Wriedt exclaimed vigorously. "You've done enough importing in most breeds. It was a real blessing to America that foot-and-mouth disease stopped the importation of Holstein-Friesian cattle from Holland. You must remember that there is only one animal in a thousand that really builds up the breed. Now you undoubtedly have many such animals at the present time. The thing to do is to find them and use them, build on them. Then you have a permanent foundation; while if you continue importing animals from Europe, even though they be individually fine specimens, they may not be just what you need to establish strong blood lines in your breeds."

"But surely we couldn't give up importing draft horses."

"Quite true. America's greatest lack, in live stock, seems to me to be a good American breed of heavy horses. But you can easily produce such a breed, if the value of it is more highly regarded. That, and the full utilization of the excellent light horses of Virginia, appear to me to be the two most promising lines of horse breeding in the United States at the present time.

"Finally, let me repeat the lesson which European experience offers to American breeders. Study the pedigrees of your breeds, hunt up the 'blood lines' that are producing the greatest number of good performers, and perpetuate, multiply, intensify these blood lines by moderate inbreeding or, if necessary, by the strongest forms of inbreeding. If this is combined with stringent selection of only the best animals, the breeder cannot fail."

[3] A good example of this is furnished by the rapid improvement of Holstein-Friesian cattle. First, the breeders have found out which are the really valuable animals—the "seven day test" is a great help to that end; second, they are able easily to trace the relationships of these animals, thanks to the convenient *Blue Book*.

GROWING MELONS ON TREES

The Papaya an Important Tropical Fruit Which Offers Great Opportunities to Breeders—Remarkable Irregularities in Sex—Changing Male Trees into Females[1]

J. E. Higgins

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THE papaya, or melon tree, is one of the most important tropical fruits and because of its delicious quality and great yield is destined, I believe, to be one of the valuable crops in the world's horticulture in the future.

Its future importance will depend largely on the work of plant breeders, to whom it offers some unusually interesting features which I propose to consider in this paper.

To those unfamiliar with the tropics, it may be said that this tree grows from a small seed to a height of 10 or 15 feet in a single year, takes on a load of fruit equal to that of a 10-year-old apple tree, and begins to ripen it about twelve months from planting. The large and beautiful yellow fruits, weighing on an average from three to six pounds, are much appreciated in the parts of the tropics where attention has been given to their cultivation, and are eaten by all classes of people. As fruit they fit into the same place in the dietary as the muskmelon, but to one who would inquire what they taste like the only reply is—they taste like the papaya.

The species has been known by many common names in Mexico, Central America and the West Indies, all of which countries have been mentioned by different writers as its probable home. In English-speaking countries it has frequently been called the papaw, but this term should be dropped since its application to the North American papaw, a wholly unrelated species (*Asimina triloba*), is well established.

The papaya will continue to bear for many years, but its period of profitable production is only two or three years, after which it is cut down to give place to young and vigorous stock. The growth is so rapid and the tissue so soft that a single stroke with a cane knife will sever the entire trunk, although it may be more than a foot in diameter. It might be supposed that so soft a structure could not support the several hundred pounds of fruit which not infrequently are borne, but since it is all carried close to the trunk and the strain is practically vertical, the breaking of a papaya tree is rare, although the large, picturesque, palm-like leaves expose a large surface to the wind.

PECULIARITIES OF SEX

From a plant breeder's point of view, the most remarkable thing about the papaya is its sex. Speaking broadly, one would say that the male and female flowers are borne on different trees. This is an unsatisfactory situation, for male trees are of no value to the grower, except in the limited number necessary for pollination. Yet when the papaya is grown from seed, as has usually been done in the past, most of the resulting plants are males, and the grower's profit is thereby much decreased.

There are two ways of avoiding this difficulty. One which is already being used is to propagate the trees not by seeds but by grafting. Then one will propagate only female fruit-bearing trees, with just a few males. This method is very useful in prolonging the existence of valuable seedlings, but it is

[1] In the present paper the author has quoted freely from "The Papaya in Hawaii," by J. E. Higgins and Valentine S. Holt. Hawaii Agr. Exp. Sta. Bul. No. 32, 1914.

HE LIKES PAPAYAS

Most people do, even at the first trial. The papaya has a medicinal value, but it is a medicine that is decidedly pleasant to take. Belief in the great future of the papaya as a food crop, however, is based not so much on its medicinal value as on its food value and its heavy yield. Photograph by Wilson Popenoe, Miami, Fla. (Fig. 7.)

somewhat expensive for a tree whose period of profitable production is so brief.[2]

The other way is to breed a race of papayas which will carry both male and female flowers on the same tree, or which will bear *perfect* flowers which furnish the pollen needed for the ovaries on the same tree. A race of this sort could be propagated from seed, and there would be no loss to the grower through the production of non-fruiting males, as at present. Every tree would be fruitful, just as is the case with the apple, pear, and most fruits.

The production of a hermaphrodite race like this is made possible by the fact that such trees exist in nature. The male flowers are not invariably confined to one tree and the female to another, but a dozen or more types of tree can be recognized; and these types form a precious material for the plant breeder. They have been described at some length in Bulletin No. 32 of the Hawaii Experiment Station, but I shall mention the more important here.

TYPES OF TREE

Form 1. The first form to be considered is the ordinary female or pistillate tree of the dioecious stock. The female tree produces flowers exclusively pistillate, with no indication of even the remnants of stamens (Fig. 8). The ovaries and the resulting fruits are of various shapes, inclining to the obovoid, with a diameter somewhat shorter than the major axis, and the surface smooth or only slightly ribbed. The fruits are usually borne singly on very short peduncles in the axils of the leaves.

Form 2. The male tree (Fig. 12), the counterpart of that just referred to, produces only staminate flowers which, however, possess rudimentary or abortive pistils (Fig. 11), and hang in great profusion in cymose panicles on peduncles 2 to 5 feet in length. The flowers, unlike those of the female tree, have a long corolla tube in the throat of which are 10 stamens arranged in two series, the one having slightly longer filaments than the other. At the base of the tube may be found a small rudimentary pistil, quite devoid of any stigma. Since all the flowers are of this type the tree abounds in pollen, but produces no fruit. In foliage and habit, other than as described, it resembles the female, and is indistinguishable until flowers appear.

Form 3. *Correae* of Solms-Laubach.[3] This form is a departure from the last and is illustrated in Fig. 11. It is identical with the tree just referred to except that a few of its flowers have pistils capable of fecundation. The rays of the stigmas may be perfectly formed or one or more may be aborted, giving rise to an unsymmetrical or gibbous fruit in which the corresponding portions of the placenta have failed to develop. The ovaries of the well-formed hermaphrodite flowers incline more to the elongated and cylindrical form than those of the pistillate tree and result in correspondingly different fruits. The corolla tube is elongated as in the staminate flowers and the stamens are similarly located in the throat of the corolla, being brought into proximity with the stigmas. These bisexual flowers are larger than the staminate but in other respects are similar, except as has just been indicated. The number of such flowers varies from few to many, there being at times as many forming fruits on the long pendulous peduncles as are to be found on some pistillate trees, notwithstanding the fact that many have fallen. Often as the fruit develops the peduncle is not strong enough to sustain the weight and breaks off, such long fruit-stems inviting disaster from the winds.

Form 4. *Elongata*, a hermaphrodite papaya (Fig. 9). This tree produces two types of flowers. One of these types is hermaphrodite and is in every way similar to a well-formed bisexual flower on the *Correae* form (form 3), except that it usually is larger and its pistil is more elongated. The other type of flower is staminate and is identical in appearance with the staminate flowers already described. Because of the presence of these two types of flowers, this form has been referred to in the earlier publications of this station as the monoecious papaya.[4]

As experiments have proceeded, however, it has been discovered that the pollen from such staminate flowers, except in the case of one tree, has failed to fecundate any pistils up to the present time, and it has been applied to every type of pistil found in the station collection. Since these flowers apparently do not function it seems incorrect at present to apply to this form of the papaya the term monoecious. They may rather be termed either pseudo-monoecious or hermaphrodite.

Form 5. Sterile hermaphrodite.

Form 6. *Forbesi* of Solms-Laubach. Briefly

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[2] It has recently been observed at Miami, Fla., that the papaya degenerates rapidly when propagated by grafting. Grafted plants of the third and fourth generations from the original seedling of the Simmonds variety develop to a height of 3 or 4 feet only, produce a few small fruits, and are always yellowish and sickly in appearance. On this account, propagation by grafting may have to be abandoned. The papaya would appear to be a promising subject for experiments on degeneration in asexually reproduced plants. It can easily be grown in greenhouses and should prove a most interesting plant for physiological experiments.—The Editor.

[3] Die Heimath und der Ursprung des cultivirten Melonenbaumes, *Carica papaya*. Bot. Ztg., 47 (1889), Nos. 44–49.

[4] Hawaii Sta. Rpts., 1910, 1911, and 1912.

PAPAYA TREE WELL LOADED WITH FRUIT

Such crops as this, quickly obtained, make it seem probable that the papaya will have an important part in the horticulture of the future. The tree here shown represents the pistillate type, all of the flowers of which are female or fruit-producing. Inserted at the lower right hand corner is one of these flowers. (Fig. 8.)

stated, the most striking characters of this plant are as follows: On the long, pendulous peduncles, characteristic of the male tree, this plant produces its three types of flowers, staminate, pistillate, and hermaphrodite. The staminate are identical with those of the ordinary male tree and the pistillate with those of the female tree, but the hermaphrodite differ from those described above (form 3). These have a very much shortened corolla tube as in the case of the pistillate flower, the lobes being divided almost to the base of the ovary. On the edge of this short tube, quite near the base of the ovary, are attached only five stamens, and these are supplied with long filaments, which rest in furrows between the lobes of the ovary. These lobes are united at the base, but often separable at the upper ends. The resulting fruit is deeply furrowed.

Form 7. *Pentandria*. This form produces hermaphrodite flowers of the same type as those just described (form 6). They have the corolla tube reduced to almost negligible length and the five stamens inserted on long filaments on this tube, near the base of the ovary. The ovary is deeply furrowed, with the stamens lying in the grooves between the lobes, thus giving rise to a deeply furrowed fruit. There are also staminate flowers of the ordinary type, and these are borne with the hermaphrodite in short clusters as in the case of form 4.

CHANGE OF SEX

It is a fact worthy of note that some of these forms are not constant. One may assume the rôle of another. Perhaps the most primary change of sex which takes place is to be observed in the appearance of hermaphrodite flowers on trees that have previously produced only staminate inflorescence. That is, form 2 may pass into form 3 or form 6. Not only is it known that such changes take place, but the conditions which may bring them about have been under observation. This "fruiting of the male papaya" takes place most freely in cool climates outside the tropics or at high altitudes. In Hawaii it may be seen that these trees fruit more abundantly on the mountains than near the sea level. In torrid climates the fruiting of the "male" is rare. It is to be remembered in this connection that all the staminate flowers of the male trees possess an undeveloped or an abortive pistil. The only change in the cases mentioned consists in the development of this pistil, resulting in a hermaphrodite flower.

It is a matter of record that complete change of sex occasionally occurs when the top is cut off from a purely staminate tree. Such treatment may result in the new tree top producing pistillate flowers exclusively, or the tree may become a hermaphrodite of the *Elongata* form. A tree of changed sex characters is shown in Fig. 13. It was formerly staminate and, being without fruit and useless to the owner, it was cut back to a stump and was used to suspend a back yard clothes line. Without any other known change in conditions it took on the fruit-bearing characters shown in the illustration and produced pistillate flowers exclusively on all of its branches. It is to be noted, however, that such changes take place with no certainty or regularity. At the Hawaii Experiment Station, the cutting back of a considerable number of staminate trees on some occasions has produced no difference in sex, while at other times a small percentage of pistillate and of hermaphrodite fruit-bearing trees have resulted.

It is worthy of note that no record has been found by the writer in the literature of the papaya which would indicate that the pistillate or female tree has ever changed its sex.

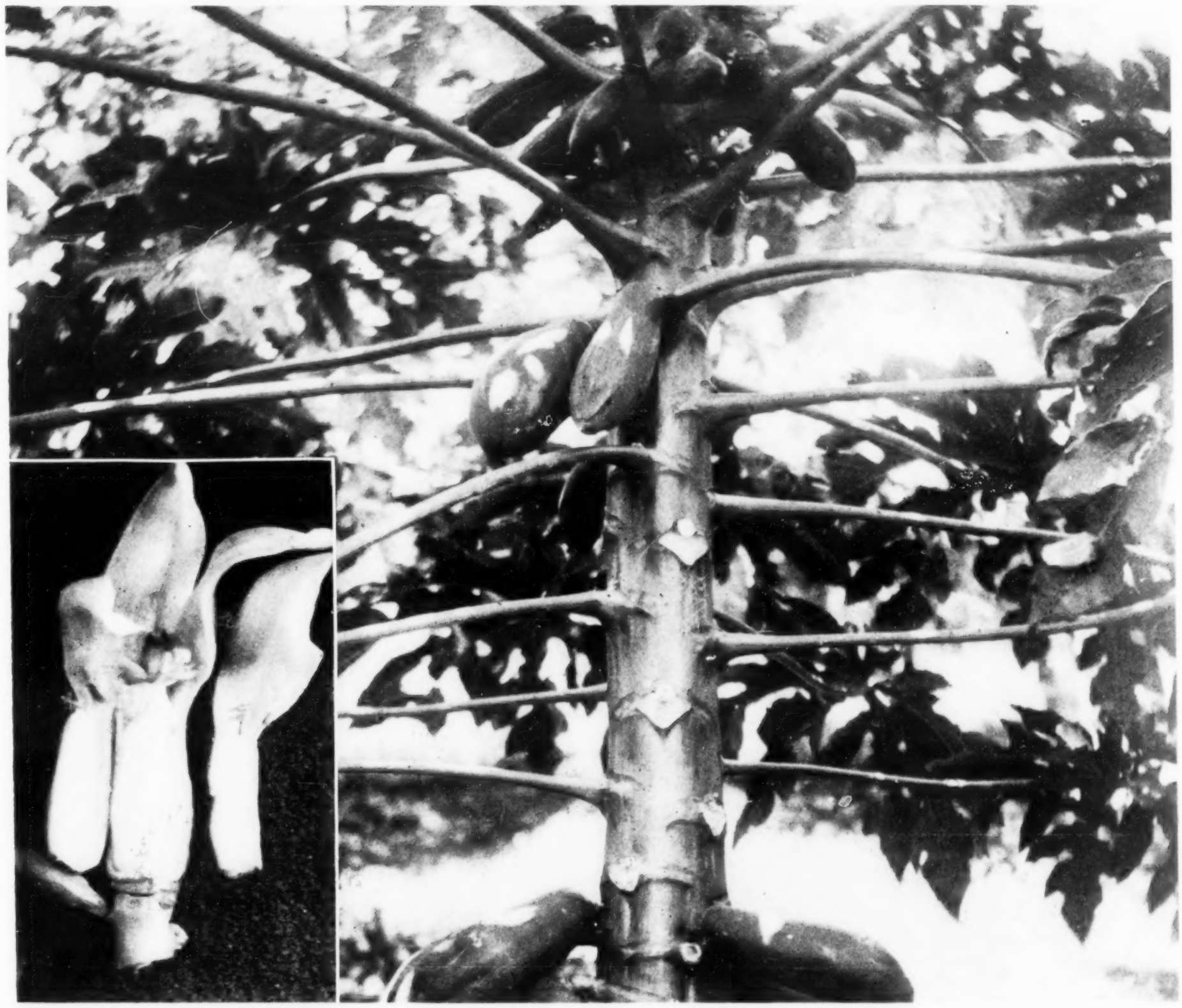
ORIGIN OF THE HERMAPHRODITE

Because the hermaphrodite form is of great importance from the standpoint of the breeder, as will be shown a little later, it may be interesting to inquire into its probable origin. It is apparent that the form *Correae* is only a slight departure from the ordinary male or staminate tree. Now comparing *Correae* with the hermaphrodite *Elongata*, it will be observed that the hermaphrodite flowers on both trees are the same and produce fruit of the same elongated form, but the trees differ only in three minor particulars: (*a*) In *Elongata* the flower clusters are greatly shortened; (*b*) It produces larger fruits usually; and (*c*) Its staminate flowers do not produce fertile pollen. It would appear that *Elongata* has been derived from the ordinary male or staminate tree, through *Correae*, by an increase in the number of hermaphrodite flowers and the shortening of the clusters and of the fruit stems.

Very little effort has been made to

A HERMAPHRODITE TREE

The Elongata type of papaya, here shown, produces two kinds of flowers. One is a male, staminate, or pollen-bearing flower, which, however, ordinarily bears no good pollen; the other type of flower is a bisexual one, the flowers not only producing fruit, but pollen as well. Trees of this type offer great promise for producing a strain that will combine the two sexes on the same plant, and not make it necessary, as at present, to have a number of male trees which, although they produce pollen, yield no fruit and therefore are counted by the grower as drones. (Fig. 9.)



AN UNDESIRABLE TYPE

This is the elongata, a more productive specimen of which was shown in the preceding illustration (Fig. 9.) In the present case, a majority of the flowers have been male, and therefore gave no fruit. The goal of the breeder will be to weed out such trees as this and keep only those which bear a minimum number of male flowers and a maximum number of hermaphrodite flowers. Inserted in the lower left-hand corner is a hermaphrodite flower from the elongata tree, showing both stamens and pistil. (Fig. 10.)

improve the papaya by systematic breeding. There has been some selection on the part of growers who naturally plant the seeds from particularly pleasing fruits. Because other forms have been little known and observed, the most of such selection has been with the dioecious papaya, and here there is an inherent difficulty even in the way of the scientific breeder. Seed from a pistillate tree will necessarily be a cross of two individuals. The characters of the female plant may be known, but those of the male plant are utterly unknown. The parent stock from which both came may be known, but since there is wide variation in the fruit of two pistillate trees from the same stock it is reasonable to suppose that there will be the same wide variation in the male or staminate trees. The variation between the pistillate trees can easily be determined because their fruits are in evidence and can be tested; but the characters which are inherent in the male or staminate tree, and which will be transmitted by it to its progeny, can be determined only through the long process of actual hand pollination, the sowing of the seed thus produced, and the testing of the fruit. Even then what portion of its excellent or indifferent qualities may have been inherited from its male parent cannot be known.

MODIFIED FORM OF THE MALE TREE

The Correae type, shown at the left, is essential a male tree which has a few flowers capable of bearing fruit. The long stems on which the fruits hang are a typical feature. At the right are shown staminate (male) flowers, one of which has been cut open to show its structure. (Fig. 11.)

Furthermore, the difficulty is increased by the fact that papaya trees usually degenerate after a few years. At least pistillate trees usually fail to produce good fruit after a few years of growth, although they may continue to produce indifferent fruit for many years. Therefore, even if the inherent characters of the male or staminate tree could be determined with reasonable accuracy, before any such determination could be made the tree would have become too old to be in a reliable state of virility if it degenerates as rapidly as the pistillate tree.

Propagation by grafting will aid in overcoming this difficulty, but it appears reasonable to suppose that the process of producing a stable variety of good quality by the use of this dioecious type would be extremely long and tedious. The hope, therefore, must lie in the use of a hermaphrodite type. Here it is possible to select an individual of known qualities. This may be used as the sole parent stock or may be combined with another parent of known qualities. What mixtures there may be in the individual at the start may not be known; but through repeated selections and the elimination of undesirable characters, it should be possible to produce a reasonably pure strain, provided, of course, that the stock is kept pure by constantly avoiding cross-pollinations with plants of different characters, a process which is necessary in all plants reproduced by seed and whose flowers are subject to accidental cross-pollination.

A further practical difficulty in the use of the dioecious type, from the standpoint of the papaya grower, as well as the breeder, is the fact that a very large proportion of the trees from any given lot of seed are likely to be

staminate, or males, and therefore useless, only a few trees being necessary to pollinate all the pistillate trees. It is impossible so far to distinguish the staminate from the pistillate trees in the early stages of their development. Therefore, in any papaya orchard planted with the dioecious type, a very large percentage of the trees must be cut out after they have grown almost to maturity, resulting in unevenness and irregularity in the orchard and much loss of time and space. For this reason, together with the difficulties of breeding, the dioecious type probably will be largely eliminated.

BREEDING HERMAPHRODITE FORMS

Turning to the hermaphrodite forms with more hope of results, we find that a number of experiments are being conducted. Here it is possible to deal with a single individual mother plant. One of the first facts to be determined is the extent to which the offspring of such a parent may be expected to be fruit-bearing trees. It was known from earlier observation, without any definite experiment, that a large number of the seeds from a fruit of a hermaphrodite flower produce fruit-bearing trees, either pistillate or, like the parent, hermaphrodite.

A tree was found in a Honolulu orchard producing fruit of excellent flavor. The fruit from which the seed was taken was of the long cylindrical form, but it cannot be stated that all the fruits on the tree were of that shape. Its flowers were apparently staminate and hermaphrodite, and so far as observed, of the Elongata form, but it is probable that the apparently staminate flowers were non-functioning. The flowers had not been hand-pollinated, and it is therefore impossible to state whether they were self-fertilized or otherwise. The seeds were planted May 2, 1910, and later thirty-five of the young plants were set in the orchard. Of these, thirty-four were hermaphrodite and one was a staminate tree. The hermaphrodite flowers on most of the trees were of two types, some of the Elongata form and others resembling Pentandria, with corresponding difference in the fruits. The best one of the trees from the standpoint of uniformity of cylindrical shape in fruit was also of very good flavor and a reasonably good producer; it was selected for further breeding. Two of its flowers were hand-pollinated each with its own pollen and carefully protected. The seeds collected from these two fruits were planted, and it was found that 94% of the resulting trees were fruit-bearing, being either pistillate or some form of hermaphrodite. This is an encouraging result, so far as the elimination of the males is concerned. It is probable that by the continued use of hermaphrodites of the Elongata form as a source of pollen as well as for the pistil-bearing parent, male forms may be largely eliminated.

CROSSING THE DIFFERENT FORMS

It has been found possible to cross quite freely most of the different forms of the papaya, as would be expected from the fact that they all are merely slight modifications of the same species. Among the experiments now in progress is one to determine the sex resultants arising from the crossing of a pistillate of dioecious origin with pollen from a hermaphrodite. If, as is expected, the progeny will be chiefly pistillate and hermaphrodite, then desired characters that may be found in any dioecious stocks may be combined with hermaphrodite stock.

Like other tropical fruits, the papaya still offers an almost virgin field to the plant breeder. But enough has been done to make it certain, I think, that a strain can be established which, combining the two sexes on the same tree, will produce from seed a desirable fruit, without the production of a great many useless male trees.

The successful achievement of this task, and the dissemination of the resulting strain, will give a tremendous impetus to the culture of the papaya. But there is still another possible field of work—namely, crossing with other species.

It is probable that there has been considerable hybridizing of Carica by natural means, and breeders have not wholly neglected the genus. I will not

A MALE TREE, THE "DRONE" OF THE GROVE

These trees produce a great profusion of pollen, but no fruit. They are consequently not looked on with favor by the grower. But under the present system of propagation by seeds, half of the trees will be of this drone type. They must be cared for until they reach maturity, for one cannot distinguish the staminate from the pistillate trees until they flower. These trees therefore occupy the land and take the time of the cultivator for a year, only to prove worthless. Plant breeders have undertaken to obviate this great practical drawback to papaya culture in two ways: by propagating, vegetatively, only fruit-producing trees; and by getting a strain which, when propagated from seed, will produce trees every one of which will bear fruit. (Fig. 12.)

CHANGED FROM A MALE TO A FEMALE

This tree started life as a male in the back yard of Dr. John T. Gulick, the geneticist, in Honolulu. As it produced no fruit, it was cut down to a stump and allowed to earn its keep by supporting a clothes line. Losing its head apparently brought a change of heart, for it proceeded to send forth new branches which were not male, but female, and bore good fruit, as the photograph shows. Such reversal of sex by heavy pruning is not rare in the papaya, but the change does not always take place when desired. (Fig. 13.)

attempt to enumerate the various species which have been crossed, since they have so far led to no commercial result. But it still seems possible that hybridization of the papaya with some more hardy species will produce a fruit which can be grown outside the tropics. *Carica cundinamarcensis* is one of the hardiest species. It stands considerable cold weather and bears an acid fruit which is pleasant to the taste when properly cooked. If this could be combined with the papaya, a hardy form might be produced which would mature a good fruit in the southern United States, for example; while the true papaya can with difficulty be made to mature good fruit even in southern California, although it flourishes in southern Florida.

IDEALS IN BREEDING THE PAPAYA

There seems to be no good reason to doubt that it will be possible to breed a papaya combining at least many of the most desirable characters and to hold the variety reasonably stable by the same means as are employed in maintaining seed varieties of vegetables and garden flowers. This presupposes segregation or hand pollination in either case, the latter being the method which most breeders will be compelled to follow because of the proximity of other varieties over which they have no control. The simplicity of hand pollination in the papaya and the large number of seeds resulting from one operation render it a very practical means even for commercial seed production.

It may be well to outline here some of the ideals which the breeder should have in mind in his search for Mendelian characters which may be combined.

1. Vigor of tree—It is important with the papaya, as with other species, to use vigorous individuals as parent stocks.

2. Early and low fruiting habits—There is a wide variation in the plants in this respect, some producing no fruit on the first five or six feet of the stem, while others bear fruit which almost touches the soil. It is believed that this character may be transmissble, and the advantage of early and low-bearing trees is obvious.

3. Freedom from the branching habit—Trees that produce side branches freely require considerable pruning to prevent the numerous new shoots from taking the nourishment which should go to the fruit.

4. Productivity but not excessive bearing—Trees that have long bare spaces on their stems and those whose fruits are so numerous as to crowd each other should be avoided in favor of such as have the fruits well spaced with just sufficient room to mature normally.

5. Hermaphroditism—The reasons for preferring hermaphrodite stock have already been pointed out. It is essential to a profitable industry that the number of "drone" male trees be kept very small.

6. Suitable size in fruit—The size that will be most desirable will depend upon the purpose to which the variety is to be put. For home use or for the fresh fruit market the extremely large varieties are not popular, and the breeder of table varieties will not, therefore, attempt to originate such forms. On the other hand there is a place for these, if the fruit is to be grown as feed for poultry or other live stock. For papain production, other things being equal, the large fruit would be best.

7. Yield in papain[5]—Where the production of papain is made an industry there can be little doubt that the average yield of this drug could be very greatly increased by judicious breeding.

8. Uniformity of shape—The breeder must seek to establish varieties which will have reasonable uniformity of shape as well as symmetry and smoothness. It is not necessary that all varieties be alike, but there must be uniformity in pack. In breeding from hermaphrodite trees there will be a large number of pistillate trees in the offspring. Although the long form is not necessarily confined to the hermaphrodite tree, nevertheless pistillate trees do not usually yield fruit of this shape. For this reason the

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[5] The juice of the fruit and sap of the papaya tree contain an active principle called *papain*, the effect of which is similar to that of pepsin. It is used medicinally, and also to clarify beer. Its digestive property is so great that raw meat placed in diluted juice will disappear altogether.—*The Editor.*

breeder may think it best to work for two forms of fruit—the long, tending to cylindrical, for the hermaphrodite, and the obovoid for the pistillate. The fruits of such an orchard would be packed as two varieties.

9. Uniformity in ripening—This is an important consideration. Some papayas ripen and decay at the outer end or the point while the inner half near the stem is too green to be eaten. The ideal papaya in ripening shows its first yellowing along the ribs about midway of the fruit and ripens uniformly toward each end.

10. Coloring before softening—Some fruits ripen with very little color, while others acquire a beautiful golden yellow when still hard, and may be kept for several days. The latter are so much more attractive on the table and in the market that they should be sought after in breeding.

11. Color of flesh—Those of pale whitish flesh must give place to the fruits of yellow, pink, or red color within. Recently some have been grown at this station with a quite decidedly reddish hue.

12. Easily separable placenta—If the placenta adheres tightly to the inner portions of the fruit and is more or less buried in the flesh, it is difficult to remove the seeds without marring the appearance of the fruit. On the other hand, it is a distinct advantage if the placenta and seeds can be readily removed without scraping the flesh.

13. Flavor—This is without doubt the most important factor to be considered. Experience has shown that specific flavors can be transmitted, and this affords the breeder an opportunity to originate and establish varieties of high quality. These flavors cannot well be described, but are easily recognized and appreciated.

14. Keeping qualities—The ideal papaya should be a good keeper, and this character has been found often enough in the fruit of individual trees to lend much encouragement to the breeder.

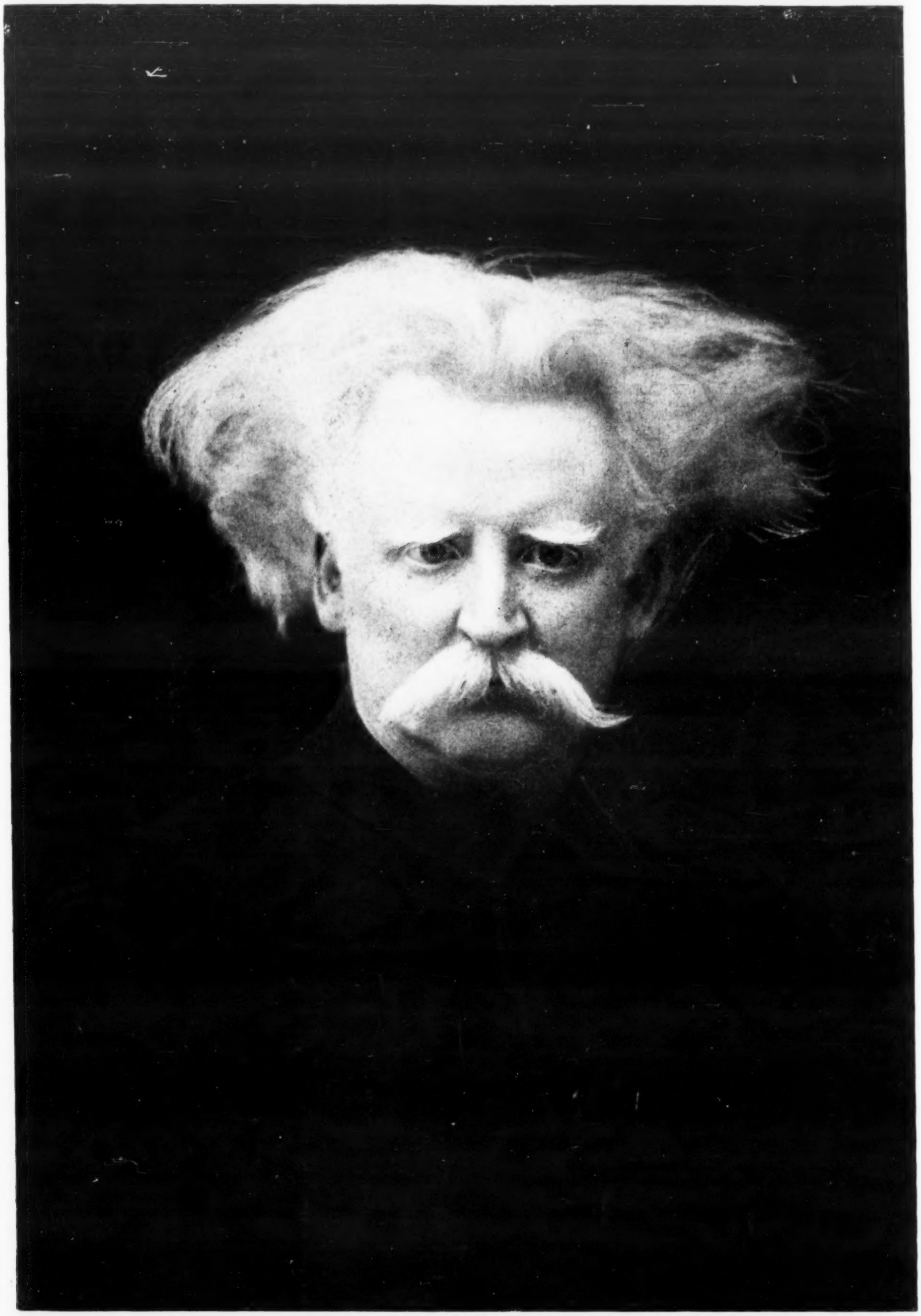
Crime and Heredity

The National Committee on Prisons has organized a committee on eugenics to consider the constitutional basis of criminalistic behavior. The inquiries into family history are to be made by a field worker trained by the Eugenics Record Office. At present, opinions of experts on the subject differ widely.

To Study Exceptional Children

In connection with Stanford University, in California, there has recently been established a research fellowship for the psychological and pedagogical study of backward and mentally defective children. The endowment is known as the C. Annette Buckel Foundation. The first fellow under the foundation was J. Harold Williams, who devoted himself chiefly to the study of the intelligence of delinquent boys, largely at the Whittier (Cal.) State School. A second bulletin has been issued by Lewis H. Terman, outlining the aims and purposes of the foundation, from which it appears that five lines of research are proposed: (1) Backward and feebleminded children; (2) delinquent or potentially delinquent children; (3) nervous, morbid, or psychopathic children; (4) children of superior ability; (5) normal children. The prospective plans for the development of the work call for an enlargement of the present foundation to include two or three additional fellowships with an annual value of $1,000 each; two office or laboratory assistants; one or two field workers to collect data on the heredity of exceptional children, and a research professorship. More remotely there is contemplated the establishment of a hospital, school or home for the first-hand study of exceptional children, and for the practical training of special teachers of such.—*Eugenical News.*

HEREDITY OF ALBINISM



ROBERT ROY (FIG. 14)

That albinism in rats, mice, guinea pigs, rabbits, etc., is inherited as a recess ve trait is the experience of all breeders. That albinism in man follows the same law is *a priori* probable but it is obviously difficult to secure cases for what is the best test of recessiveness, viz., the exclusively albinic progeny of two albinic parents.

Some years ago Mrs. Davenport and I recorded (*American Naturalist*, December, 1910) three pedigrees giving the progeny of the matings of two albinos.

MRS. ROBERT ROY (Fig. 15)

They were all based on the statement of Robert Roy, of New York City, whom I have always found trustworthy. These families were recorded as the Luc. family, two children, both albinos—of albinic parents; the Pri. family, one albinic child of two albinic parents; and the R. family, an albino child of two albinic parents. The surname of this last family which we did not then feel at liberty to divulge, but which we are now permitted to publish, is Roy. Robert Roy (Fig. 14), of New York, now about fifty-five years of age, was one of a fraternity of ten, all but himself pigmented—one with jet black hair. Their father had very dark brown hair and their mother sandy hair. Robert Roy married, about 1880, a Miss

THEIR SON, K. C. ROY (Fig. 16)

Annie L. W. (Fig. 15), with whom he was associated in shows. Three other of her fraternity were albinos and eight were pigmented. Their only child, born, like his mother, in Pennsylvania, was King Charles Roy (Fig. 16). The resemblance of the son to his mother is marked in the lower parts of the face; to his father in the upper part of the face. I may add that the albinism is practically complete in father and son; there is no nystagmus but rather marked photophobia, especially in the son.

C. B. Davenport

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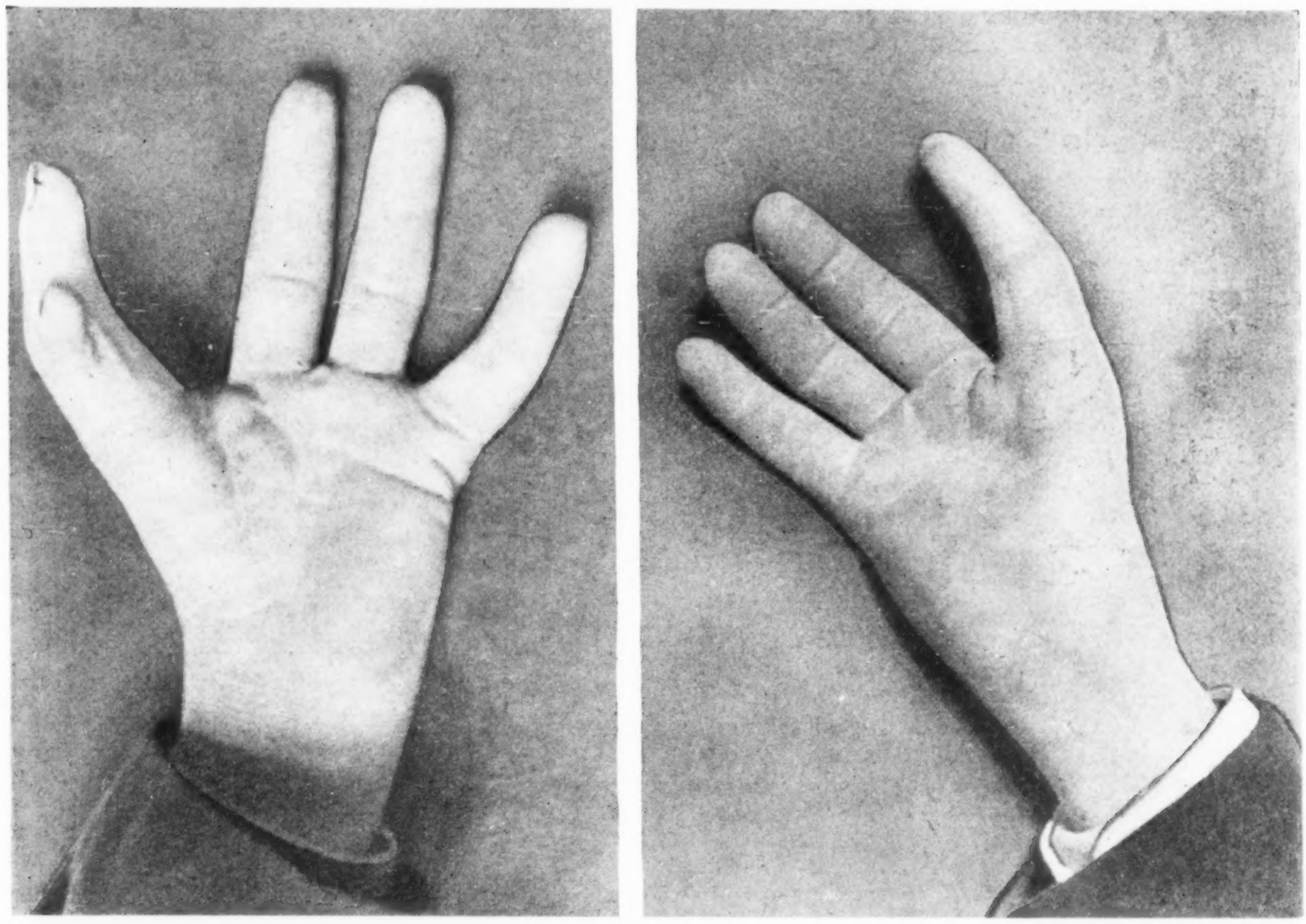
A FAMILY WITH ABNORMAL HANDS



The possessor of these hands recently arrived at Ellis Island, N. Y., where he was examined by Asst. Surg. Howard A. Knox of the United States Public Health Service. Inquiry showed that his father was normal; the paternal grandmother had webbed fingers on both hands, but the fingers involved could not be learned; a paternal male cousin had deformities exactly like those shown here, except for the rudimentary digit growing from the first finger of the left hand in this case; a sister of this cousin was described as an imbecile. The case well illustrates how a stock of rather low mentality is often characterized by physical defects, which are evidently due to heredity though not identical in each generation. Photograph from the United States Public Health Service. (Fig. 17.)

Inheritance of Fertility in Swine

Study of 3,540 litters of pigs is reported by Edward N. Wentworth and C. E. Aubel in the *Journal of Agricultural Research* (March 20, 1916). Previous studies had indicated that fecundity is to some extent an inherited character, although the degree of resemblance between parent and off-spring in this respect is not large. Cross-breeding has given some reason to suspect that a number of distinct, inheritable factors influence fecundity; it is also certain, of course, that fecundity is influenced by numerous factors which have nothing to do with heredity. The analysis of data showed some evidence of the presence of three distinct hereditary factors, but further research will be required before any result can be announced with confidence. The study is obviously an important one, in view of the great value of high fecundity in domesticated animals.

BREEDING NEPHROLEPIS FERNS

"Ever-Sporting" Types and the Methods of Propagating and Disseminating Them—New Forms May Be Obtained from Spores of Nephrolepis Ferns—Suggestions for Practical Growers

SARKIS BOSHNAKIAN

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FERNS of the genus Nephrolepis (of which the popular Boston fern is the best-known representative) can be divided in two groups, on the basis of their genetic behavior; first, those which show variation only when propagated sexually, by spores; and second, those which produce new varieties asexually.

The first group includes more than ninety species and varieties, all of which are either found growing wild in semi-tropical regions or have been produced from spores by breeders. Of these may be mentioned the widespread commercial varieties *Nephrolepis exaltata, cordata compacta, plumosa, davallioides, canaliculata*, and so on.

The second, and more interesting, group is limited to the Boston fern, botanically known as *Nephrolepis exaltata bostoniensis*, and all its sports, of which we have many.

In a state of nature, ferns are often hybrid. The sexual organs are located in such a position as almost wholly to prevent self-fertilization. The spores, found in large numbers as kidney-shaped, brown, fruiting bodies on the under side of the leaflets, produce occasionally new forms when sown. So far as results show, the ferns of the first group breed true when propagated asexually, and in England a large number of new varieties, such as concinia, and Mayi have been produced in this way from seedlings.

The ferns of the second group, that is those derived from the asexual variations of the Boston fern, may also be propagated from spores, despite the general belief that the spores are sterile. I have raised a number of seedlings from the spores of the Boston fern and of some of its sports; those with finely divided leaves produce no fruiting bodies, but the others with uncrested leaflets yield spores in abundance.

GERMINATION IS SLOW

It is considerably harder to grow the ferns of the second group than those of the first, or of other genera. The ferns of the first group with the exception of a few, such as *N. davallioides, N. d. furcans*, and perhaps some others, germinate promptly at the end of a certain number of days. *N. exaltata*, for instance, takes twenty-six days to germinate, and *N. plumosa* twenty-four; all the spores germinate at almost the same time. Such is not the case, however, with the Boston ferns. Out of thousands of spores, only a few may germinate at the end of a month or more; the rest keep appearing, a few at a time, for many months afterward.

They are very sensitive to the amount of moisture which surrounds them; and since nowhere, so far as I know, are directions given for germinating the spores of these plants, it may be useful for me to discuss the subject before proceeding to treat of the more usual, asexual method of propagation.

In an experiment to determine the best medium in which to sow Boston fern spores, different materials, such as loam, sawdust, paper pulp, filter paper, asbestos, cinders, cotton and leaf mold were used. The comparative efficiency of different containers was also tested. The results showed that the best medium was well-decayed oak-

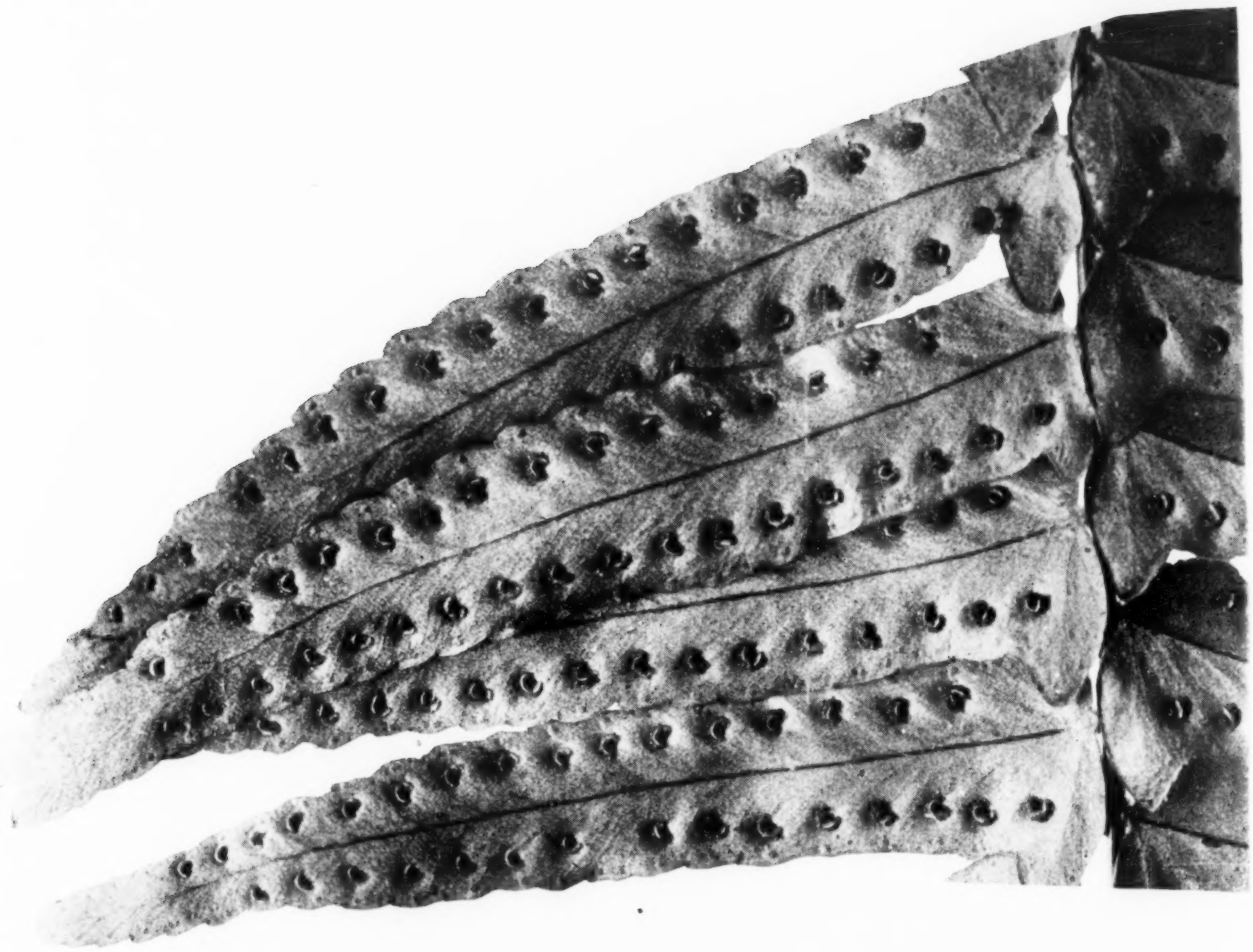
THE ORIGINAL BOSTON FERN

This fern, familiar to every plant-lover, has been particularly useful to breeders because it is constantly producing new forms—it is an "ever-sporting" variety. From this parent type sixty-five new varieties have been introduced to the trade, some of which have proved valuable and been retained, while others which were not of superior value in any one respect have disappeared. Probably the possibilities of the Boston fern are by no means exhausted, and it therefore offers an attractive material for amateurs as well as commercial breeders, since it can be propagated indoors, with little space, and there are no great difficulties to be overcome or expenses to be incurred. (Fig. 18.)

leaf mold. The advantage of this lay in its moisture absorbing and retaining property. The surface of leaf mold being uneven, the spores sown will fall on the projecting tips of the small pieces of leaf mold where the moisture hardly rises by capillarity but the spore is surrounded with a saturated moist atmosphere; they may also fall down in between the leaf particles where they come in contact with a microscopic film of moisture. All the intermediate conditions exist also, so that no matter what the moisture requirement of the spores, some of them will fall in a position where conditions are favorable.

As to containers, a clean pot not less than 6 inches in diameter seems to be the best suited for commercial work. For research work, where the exclusion of any foreign spore is necessary, the use of large preparation dishes with a depth of at least ¾-inch gives the best results.

The preparation of the medium in which to sow the spores differs also from that suggested for other ferns. The bottom of a clean pot of two-thirds



THE FERN'S REPRODUCTIVE ORGANS

The crescent-shaped masses found on the backs of many fern leaves are *sori* or aggregations of spore-cases. From a commercial viewpoint their presence is a drawback rather than an advantage—they are unsightly and not needed since in cultivation the fern is ordinarily propagated by runners rather than by spores. (Fig. 19.)

depth is filled to about 1½ inches in depth with clean broken crocks and large pieces of cinders. Over this, finely screened leaf mold is placed and is packed down somewhat firmly. The surface of the leaf mold should be about ¾-inch below the upper edge of the pot. The leaf mold should never be sterilized. Sterilization of the leaf mold is not desirable because with the cooking or baking of the leaves during the process of sterilization toxic substances are produced. This process also kills all living organisms, so that when spores of fungi or molds fall on the surface of this sterilized medium, they are absolutely free from competition, and they grow rapidly over the surface of the pot, either destroying the fern spore or giving off poisonous products which prevent the spore from germinating.

Since Nephrolepis ferns are not found wild in North America, leaf mold which the grower procures from the woods may be considered absolutely free from such spores. The pots are to be filled with this compost, and boiling water then poured over the contents, to kill grass seeds, worms and insects which may be present. Most of the seeds present will be destroyed after 20 minutes, and the surface of the leaf mold in the pot will then be almost sterile. As soon as it cools down, a little finely screened fresh leaf mold is scattered over it. The soil in the pot is thus inoculated with ordinary soil bacteria which grow very rapidly and spread over the surface; spores of fungi falling on a soil thus quickly populated with soil-bacteria will make a very small growth or none at all, but the germination of the fern spores is not interfered with in any way.

A GROUP OF SPORANGIA (SPORE-CASES)

Each of these capsules (here magnified about 100 times) contains a large number of ovoid spores, the reproductive cells, three of which can be seen in the upper left-hand corner. Although this method of reproduction is called sexual, the spores themselves have no sex—or rather, they are a combination of the two sexes in one. When they become ripe they are shed upon the ground, where they germinate and give rise to little sexual plants, called *prothalli*, shown in the next illustration. (Fig. 20.)

After the spores have been sown on the surface of this medium, the pot is covered with a piece of glass and then set in a saucer filled with water, in a partly shaded propagating frame. The saucers are placed on clean cinders over which lime has been scattered. This keeps away insects, worms and molds. At the end of four weeks or more the spores begin to germinate and form the so-called prothalli—heart-shaped, leaf-like plants which attain a diameter of a quarter of an inch, when fertile. From each of these develops a new fern. When the first leaves appear the prothalli should be removed in small clumps or singly with a pair of forceps and planted half an inch apart in flats or pans containing leaf mold to which a little finely sifted soil has been added. Later they are transferred into 2¼-inch pots.

The seedlings obtained in this manner are, as they grow, carefully watched for the appearance of new types, which are isolated and studied.

Most of our commercial varieties are sports of *N. exaltata bostoniensis*. This variety probably originated near Boston some thirty years ago. The first recorded sport of commercial importance occurred during the early part of 1898 and since then there have been produced over sixty-five commercial varieties of which about fifty are of American origin.

In order to produce new types it is necessary to raise a large number of

different varieties. This can be profitably practiced by persons who are engaged in growing ferns for commercial purposes, because they have under their observation a large number of plants which they are already growing for the market. The plants during their development are closely examined and those which show a tendency to differ in foliage or in habits of growth are isolated and grown directly in benches.

The somatic variations, such as are found among ferns, may occur in a portion of a frond, or on the stem or root stock, or on the runners. The only variations which are of any value to the breeder are those which can be isolated. Not all variations can be utilized.

WILL NOT GROW FROM CUTTINGS

There is no way of isolating a variation which occurs on a portion of a frond, for unlike some ferns and certain dicotyledonous plants, a portion of the leaf cannot be induced to strike roots to form an independent plant when brought directly in contact with soil.

When the stem is above the level of the soil and an entire frond happens to differ from other fronds which arise from the same stem, the probabilities are that the variation or the somatic mutation, as it is sometimes called, has taken place on the stem. It is necessary to plant them deep enough to cover the base of the leaf which one wishes to isolate. Most of the old leaves are removed in order to allow the development of new fronds. If the variation has occurred in the stem it is likely that the new fronds arising from the base of the sporting leaf will resemble one another. On account of the depth at which the plant is set the base of these fronds including a portion of the crown will tend to strike roots.

It must be remembered that this is not a sure method of separating a sported plant. In order to obtain the expected result there are three conditions which must be satisfied. In the first place the sported portion must extend over a considerable area around

FERN PROTHALLUS

This peculiar little plant (here magnified more than fifty times) grows from the fern spore and lies flat over the ground. It contains the male sexual cells (antheridia) at the region marked ♂, while there is a female reproductive cell or archegonium at the point marked ♀. When ripe, the antherzoids make their way towards the egg cell with which one of them unites. This fecundation starts the growth of a fan-shaped leaf-like structure, the base of which strikes roots and becomes an independent plant, whereupon the prothallus dies and decays. This indirect method of reproduction in the ferns is remarkable, ferns not giving rise directly to ferns, but rather to prothalli. (Fig. 21.)

the base of the rachis of the leaf (called the stipe); in the second place, from this region new fronds should develop which will be like the sported frond observed; and thirdly, this region must root in such a manner that it will develop into an independent plant which it will be possible to isolate from the mother plant.

For a sport of the second type, that is, when the variation takes place on a portion of the crown, the time it takes to satisfy these three conditions may vary from several months to a year or more, in some cases a negative result

IT REALLY IS AN "EVER-SPORTING" VARIETY

This Boston fern shows variations in size and shape of leaflets in every part of the plant. It is a curiosity to the geneticist, but almost worthless from the standpoint of the practical breeder, because these small variations will probably not "breed true." Frequently, however, a whole plant varies from its parent in some striking way; and such sports as that are perpetuated and form valuable new varieties. (Fig. 22.)

being a possibility. For this reason unless the variation is absolutely new it is not profitable to keep the plants very long and rely upon the law of chance.

SPORTS ON RUNNERS

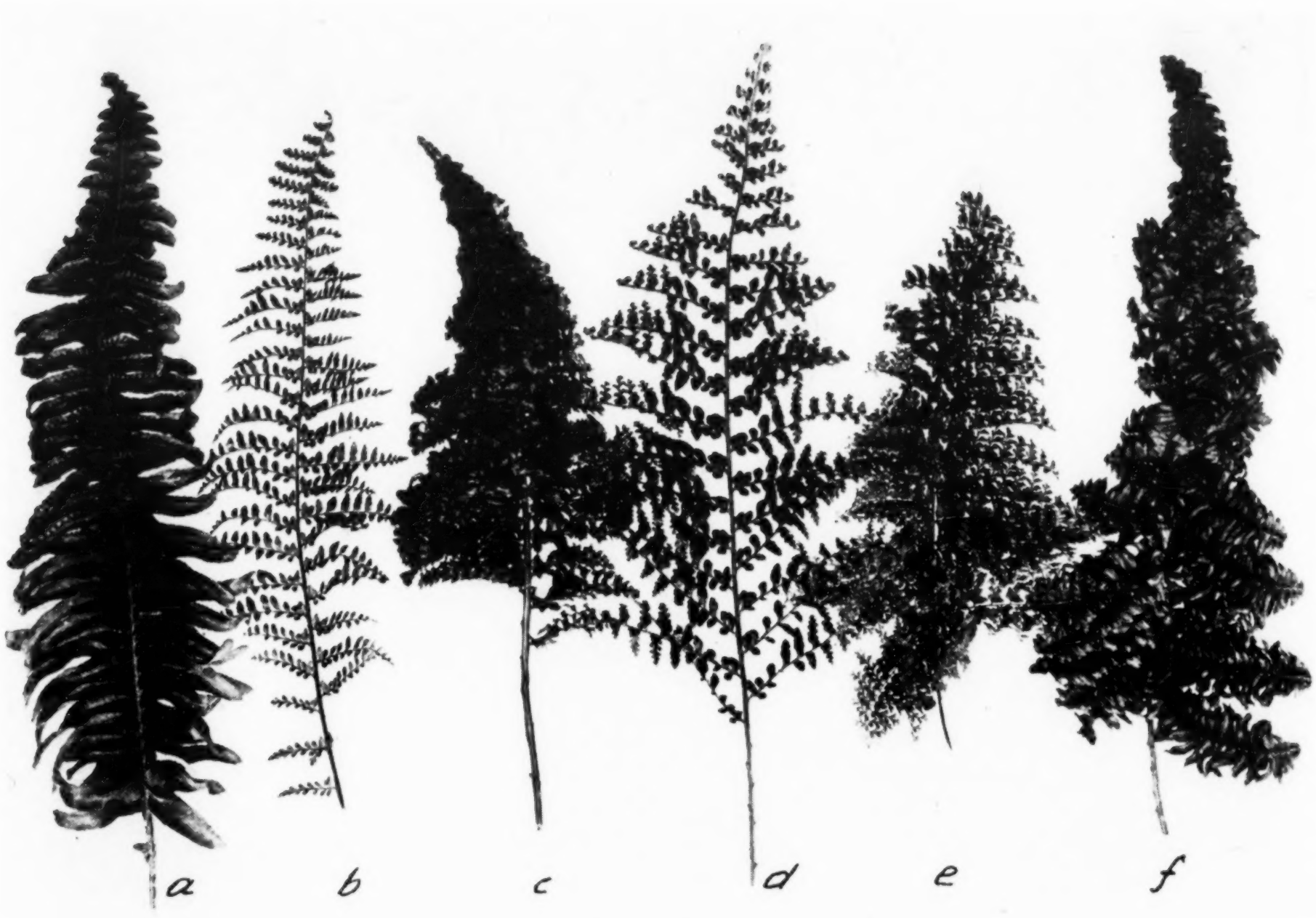
The sports which are commercially utilized and which are easiest to isolate are those which appear on some portion of the runner where new rooted fronds are produced. When such a new type is discovered the entire plant with its runners is lifted from the bench, care being taken not to disturb the soil around the root system, and transplanted to a separate bench where the plant can be closely and frequently examined. The leaves of the mother plant near the sported fronds are cut back, for in this way more light is allowed to reach the new fronds and development of new buds is thus encouraged. It is a good plan not to sever the new fronds from the parent plant until the former has made about five leaves, for until that time the small fronds are nursed by the mother plant. At this stage the original plant may be removed by cutting the runner which connects the two plants. In order to produce more fronds and allow the rooting of runners a little soil is sifted over the plant to bury the crown. Some growers object to this method claiming that such a practice tends to produce decay at the base of the leaves, but after having practiced this method many times, and in some instances even after burying the crowns about an inch below the surface of the soil, I have never observed decay to take place; but on the contrary, in an experiment with *N. viridissima* to see the effect of deep planting I found more leaves on plants whose crowns were set one-half inch below the surface of the soil, than on plants which were not planted deep.

While the plant is developing in size the commercially desirable and undesirable characters as well should be studied, for it will be a waste of time and of valuable space to multiply a plant which is commercially worthless.

The following are the characters which are to be considered in determining the merit of a new fern:

The plant must be either an *improvement over another form* or be *a class by itself*. As we have already a good many types the chances are that the new sport will resemble some other variety; and unless it is an improvement over those already existing, the demand for it will be very slight. The improvement may not necessarily be in all characters, but no matter how few these improvements, they should be pronounced and striking enough to make the variety better than any already on the market. When *N. Piersoni* was being introduced in 1903 it received many prizes and was in great demand for some six years. It is now out of the market because other varieties with similar type of fronds, such as Whitmani and elegantissima with their "compacta" and "improved" forms, show such marked improvements in their habits of growth. But varieties like superbissima and its derivatives viridissima and muscosa being unlike other ferns cannot be compared with other forms; therefore, being a class by themselves, they have created a market of their own.

Those ferns are most profitable which can be raised to a marketable size in the shortest period of time. This period varies with the *rapidity of growth* of the plant. There are three growth characters which are desirable: in the first place the fronds should develop rapidly; in the second place numerous buds should arise in the central area of the plant to give it a dense form; and finally it should send out runners freely. The last character is especially important from the view point of the wholesale florist, as the latter is concerned mainly over the rapid propagation of the plant. Beauty and attractiveness alone without rapidity of growth do not make a new variety a commercial possibility. There are a few nephrolepis ferns which receive prizes wherever exhibited, but due to the fact that they are slow growers their sale is limited to private collections. On the other hand, ferns like bostoniensis and Scottii which originated



SOME DESCENDANTS OF THE ORIGINAL BOSTON

These leaves of modern commercial varieties show how widely some of the sports differ from their parent. Their trade names are as follows: *a*, *Nephrolepis viridissima; b*, *N. Millsii; c*, *N. muscosa; d*, *N. verona*, *e*, *N. magnifica; f*, *N. superbissima*. While these forms are relatively stable, they are all likely in turn to give rise to valuable new sports, from time to time. (Fig. 23.)

respectively about thirty and fifteen years ago, by virtue of their rapid propagating habit are still favorites. They are leading commercial varieties in spite of the presence of numerous competing sorts of recent introduction.

UNIFORMITY IS NECESSARY

Not less important is the *uniformity* of the size and shape of the smaller leaves known as pinnae. The plant should not show a tendency to "revert" or show any variation in any part of the leaves. Such a plant should not be allowed to appear on the market, for besides being a failure, it may sometimes affect the reputation of the firm which introduces it. In most cases it is possible to produce a pure-breeding strain by subsequent propagations by divisions. Some ten years ago, when few varieties existed, a number of them, such as Piersoni and Fosteri, in spite of their constant reverting habit were able to remain on the market for a number of years. But now that we have so many varieties, competition is very keen, and unless the plant proves to be a uniform breeder its introduction should not be allowed. From what has been said above, one should not be led to conclude that all commercial varieties will breed absolutely true. All of the sports of bostoniensis occasionally revert back to the original type in different degrees, and so far as I know this cannot be avoided entirely. For this reason the trade makes allowances for rare reversions. But plants which revert frequently find no place on the market.

Symmetry of the plant is another desirable character. Lack of symmetry is to some extent due to defective methods of potting, exposure to light, and careless overhead watering, yet in

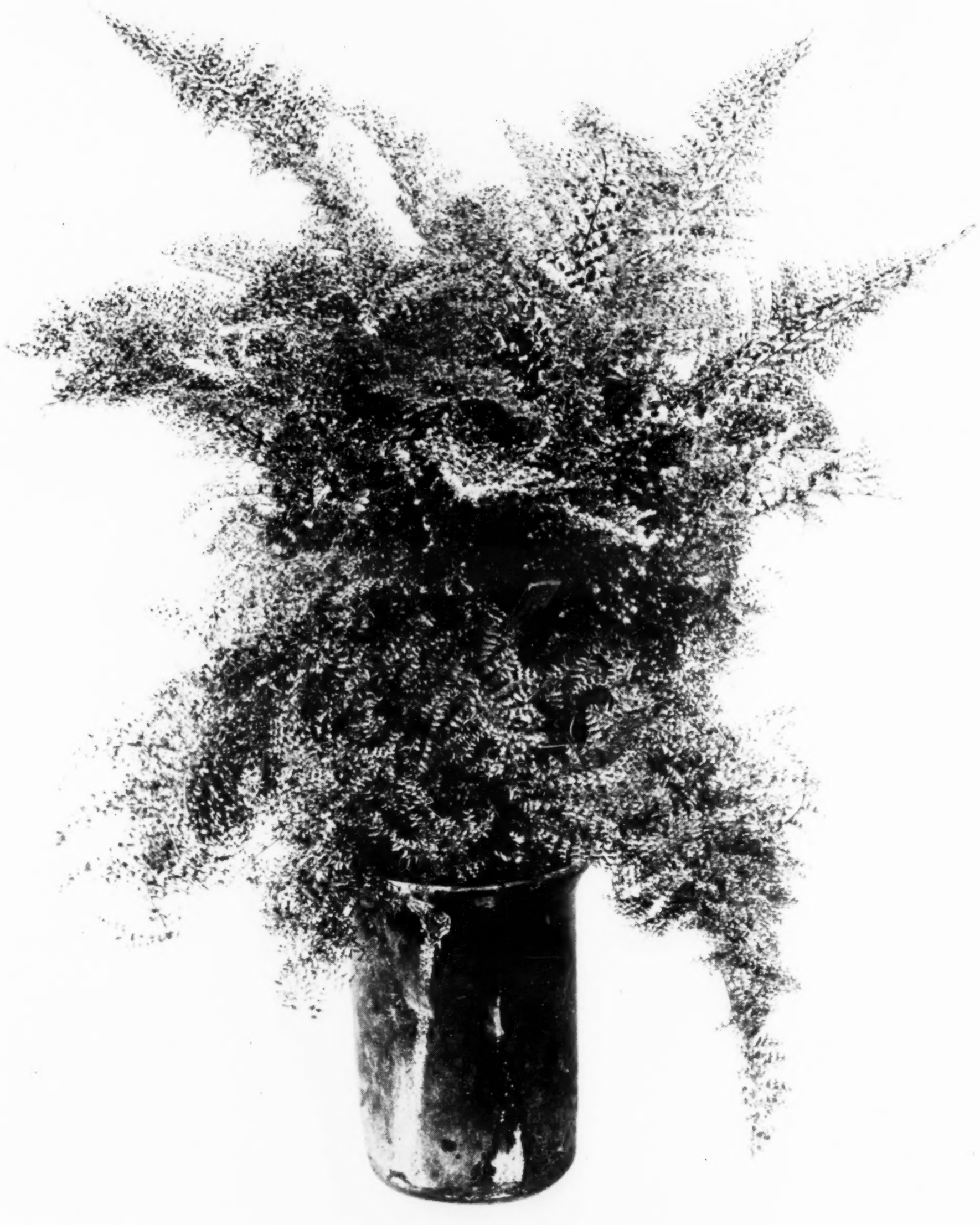
THE APPEARANCE OF NEW VARIETIES

At the right (*b*) is *Nephrolepis magnifica*, a dwarf asexual descendant of the original Boston fern. *a* is a sport from this dwarf, and differs widely from its parent, particularly in showing greater vigor. It has one undesirable characteristic—namely, that its roots sport, and therefore it cannot be depended on to breed true. At *c* is shown a little frond sporting back to the mother (*b*) type. *d* is another root sport, not very different from the original Boston, but with the drawback that it is inconstant. By further division of this form *d*, a constant variety of value might be obtained. (Fig. 24.)

many cases the natural habit of growth of the variety is responsible for these defects. A variety with a rank growth of fronds is most likely to produce an unbalanced plant. Dense and bushy plants are least liable to lack symmetry. Multi-pinnate, that is, finely divided ferns, such as Smithii, and Goodii, unless they be large specimens, grow unsymmetrically. In these and similar varieties the defect is due to the weakness of the rachis of the leaves. The rachis can hold the frond upright so long as the latter is small; but when the fronds develop to full size they become heavy and hang down, spoiling the symmetry of the plant. A tri- or multi-pinnate fern with a heavier rachis that can support the weight of the developed frond will create a ready market. A sport of Smithi recently introduced under the name of *N. verona* seems to possess this desirable character and its outlook is promising.

Sori or masses of spores on the underside of the leaves are objectionable, because they form undesirable brown spots of considerable size; and furthermore when these ripen, the spores fall on the surface of the leaves below giving them a rusty appearance. Ferns with finely divided leaves, and young plants plants with undivided leaves, are free from spores, but the latter in most cases begin to produce spores when they get old.

On account of lack of air circulation at the base of the plant, in some forms



A DELICATELY GRACEFUL VARIETY

The descendants of the Boston fern differ widely (as was shown in Fig. 23) in the extent to which their leaflets are divided. The form here shown, *Nephrolepis Smithii*, is the most finely divided of all the commercial varieties, and therefore possesses an appearance of lightness and airiness which has made it a great favorite. (Fig. 25.)

compactness of foliage causes decay of the center of the plant. This is especially evident in those varieties whose leaflets are very thickly set on the rachis. Such forms, if possible, should have an *open center*.

When the originator is convinced that his plant conforms with the desirable characters just discussed he should begin to increase its numbers. This is best done by planting the fern in a bench and allowing plenty of space around it for the runners to radiate in all directions. These runners, like those of the strawberry plants, root at intervals and give rise to new small plants which can be easily severed after they have made five or more leaves. These little plants are first potted in small pots; in late spring or early summer these are again planted in benches where they are allowed to develop and produce runners. The new plants arising from these are severed in the same manner as before, and the practice is repeated until the desired number of plants for introduction are obtained.

INTRODUCING A NEW VARIETY

The success that the new variety will have on the market will depend entirely upon the proper methods of introduction. There are many instances where a certain variety has been sold on a very large scale although there has been a similar variety already on the market; but because of lack of proper methods of introduction the latter has had little more than a local sale.

Since this paper has been prepared primarily for the practical breeder, it will not be out of place to give in conclusion brief suggestions of the best procedures which should be followed in the introduction of new varieties of ferns.

The number of the plants which the originator should have on hand before introducing depends entirely upon the degree of his ability to dispose of the plants and upon the excellence of the variety itself. For a good variety, from 5,000 to 30,000 plants and even more will be necessary. Depending upon the ease with which the runners root it takes from three to four years to obtain them. The first customers are usually the wholesale growers of ferns who buy the plants in order to produce larger ones after growing them for some time. They offer them to the market while the supply is still limited. The originator must naturally have enough on hand to supply these growers and to keep on supplying ferns while the latter are developing their stock of plants. The minimum time required for growers to put their stock on the market is probably six months. During this period the introducer may have a monopoly on the stock, and being free from competition can hold his price high.

If, due to the lack of necessary greenhouse space, the grower cannot multiply his plant to the desired number, he will find it profitable to communicate with one or more large wholesale growers who will agree to raise part of the stock and return a certain percentage of the profit from the sales. There are, of course, many other agreements which can be made. In the case of *N. Amerpohlii*, for instance, part of the stock was shipped from Janesville, Wis., where it originated, to two wholesale growers in Philadelphia. When the stock had been increased, it was offered for sale simultaneously by these three firms.

It will usually be found profitable to disseminate a new variety of fern in spring. When some of the greenhouses, especially carnation houses, are vacant during late spring and summer months, the benches can be profitably utilized for the growing of ferns. It is not necessary to change the soil for these plants. Violet houses are also excellent for ferns in summer. The runners root before the benches are needed for the regular crop. These rooted runners may be potted in 2¼-inch pots. By the following spring they develop good sized plants. Another advantage of spring dissemination is the opportunity of exhibiting specimen plants at the fall flower shows.

As wholesale buyers are very critical about a new plant which has not yet stood the test of time, no effort should

be spared in showing all its merits. It is advisable not to begin to advertise until three or four months before the time set for dissemination, or a few weeks before some important flower show, so that those interested may eagerly look for the new plant at the exhibitions. If it is advertised too early people are apt to forget about it by the time it is to be introduced.

Skillful and attractive methods used in advertisements and displays will almost entirely determine the reception and success of a newly introduced fern.

Genetics in Education

One hundred colleges or universities in the United States are giving courses specifically in either eugenics or genetics during the present school year, according to a census made by the *Eugenical News*. This list does not include the agricultural colleges, which present much of the same material in their courses on breeding.

Unusual Fecundity in a Cow

A remarkable case of fecundity in a half-blood Hereford is reported by E. C. Wetherbee, Jr., of Marshalltown, Iowa, a member of this Association. The cow, which belongs to William Harkemeyer of Benton County, was herself a twin, born in June, 1909. In December, 1911, she dropped two calves; December, 1912, one calf; January, 1914, two calves, and December, 1915, three calves.

Feebleminded Adrift

There are about 15,000 feeble-minded in Massachusetts, of whom 3,000 are now receiving State care, according to the League for Preventive Work (Boston) which has just published a booklet with the title "Feebleminded Adrift." Of the 12,000 for whom no State provision is made, many are protected in good homes. Another group are sexually passive, industrially competent, and capable of adjusting themselves to community standards. For neither class, it is declared, is State segregation necessary or desirable. Approximately 2,000, however, can always be found in other public institutions. Those committed to insane hospitals are usually held in permanent custody; the others drift in and out of almshouses, prisons and reformatories. These 2,000, therefore, a constantly shifting group, represent many thousand unprotected feebleminded in the community, for whom custodial care is essential.

The development of State schools for the segregation of the feebleminded, it is pointed out, meets the requirements of economy, justice and efficiency. Their per capita cost for maintenance is less than that of other institutions. They furnish a simple environment which is adapted to the needs of defectives and which enables them to live happily on their own plane. They offer specialized industrial training which renders many of the inmates wholly or partly self-supporting within the institution, transforming them from demoralizing and destructive forces into productive members of the State. They furnish protection both to Society and to the feebleminded for whom community life means danger and exploitation. And finally, by permanent segregation, they prevent the procreation of a new generation of defectives, thus cutting off at the source one of the greatest of social ills and striking at the root of the physical and moral degeneracy, pauperism and misery, alcoholism and crime, with which feeblemindedness is inevitably linked.

The Massachusetts State Legislature of 1915 appropriated $50,000 for the purchase of 880 acres of farm land near Belchertown, in the western part of the State, and it is hoped that the present legislature will appropriate $150,000 annually for five years, for the construction of buildings to house 1,000 inmates.

EUGENIC SURVEY OF NASSAU COUNTY, NEW YORK

BY A GIFT of $10,000, the Rockefeller Foundation has made possible the immediate beginning of a eugenic survey of Nassau County (Long Island), N. Y. It will particularly attempt to find the amount of mental deficiency existing.

During recent years, the burden of caring for defectives has in many States become almost crushing. New York is now spending more for the insane alone than for any other purpose except education, the amount being about one-fifth of the State's total revenue. Massachusetts is spending one-third of her entire income on the support of those who require state care. In many other States the problem is rapidly reaching similar proportions.

The growing recognition that many—perhaps the greater part—of these defectives are the product of defective heredity, has brought a realization that the stream can, without much difficulty, be greatly diminished at its source.

The first requisite is to know the facts in regard to the distribution of defect in an unselected population. Hitherto, studies have been made largely in institutions, and there has been no comprehensive study of an ordinary population. Nassau County, with a population of about 100,000 in a rather small area, divided between farms and towns, seems to offer a good opportunity for ascertaining the conditions in a community that is probably fairly typical of a great many in America, and some of its residents have been public-spirited enough to undertake the work of making as accurate as possible an estimate of the number and kinds of mental defectives at large, in order that the State may better be in a position to consider what the situation demands. It is well known that the number of defectives now receiving State care is only a part of the number which ought to receive such care; but no one knows what proportion. The Nassau County survey will help to answer this question for the State of New York, and to a less extent for other eastern States.

MENTAL TESTS TO BE USED

The first step will be to select for special examination all those children and adults who are known to the educational, poor-law, police or health authorities as having failed to hold a normal place in the community either by reason of unteachableness, or moral deficiency, or imperfect social adaptation. This will mean the examination of backward, atypical or unruly children in schools, children and adults in almhouses and other institutions, inmates of prisons and others known to the police, children and adults in receipt of outdoor relief, persons known to the medical profession or others as being possibly defective.

The examination of these people will consist of an inquiry into the family, social, and personal history, and a series of mental tests.

But the collection of data regarding these abnormal persons would possess little value, unless at the same time data were secured about the normal individual living in the same environment. The survey will, therefore, undertake to secure information about *every one* in certain selected districts. The information about those who are apparently normal will not be so full as about those who are apparently defective; but there will be an endeavor to get a certain minimum amount of information about each one, which would establish his normal mentality and would make possible eventually the construction of normal statistical social standards for the county, pertaining to the facts of heredity, progress at school, and amount of education, occupations and earnings,

social position, civil condition, fertility, and physical health.

The labor, therefore, will consist of the examination of selected persons in all parts of the county and all persons in selected parts of the county. It is estimated that this will take at least four months, and that several months more will be required for working up the data. The State of New York has furnished the services of Dr. A. J. Rosanoff, of King's Park Hospital, to direct the survey; with him will be one or more medical examiners furnished by the United States Public Health Service, eight field workers to investigate the family histories of the individuals examined, and several clerical assistants. Headquarters will be at Mineola, the county-seat.

General direction of the survey will be in the hands of a committee, consisting of Dr. Charles B. Davenport, chairman; Samuel P. Duggan, Elizabeth E. Farrell, Homer Folks, Dr. August Hoch, Dr. A. J. Rosanoff, and Dr. Thomas W. Salmon. The survey was initiated and will be partly financed by the Nassau County Association, a citizens' organization which has hitherto taken an active interest in the problems of eugenics and cacogenics in its district.

Genetic Survey of Kansas City

"The Southwest School of Hygiene of Kansas City, Mo., under the directorship of Dr. Belle S. Mooney, is organizing a Eugenic Survey of the city with the cooperation of the Board of Education," says the February *Eugenical News*. "The plan is to secure the family history of all the school children and not simply the history of the backward children. This is an important step in the right direction. No class of society can be rightly studied apart from its fellows. Our studies of human heredity have thus far been too one-sided." This will make a valuable check on the Nassau survey.

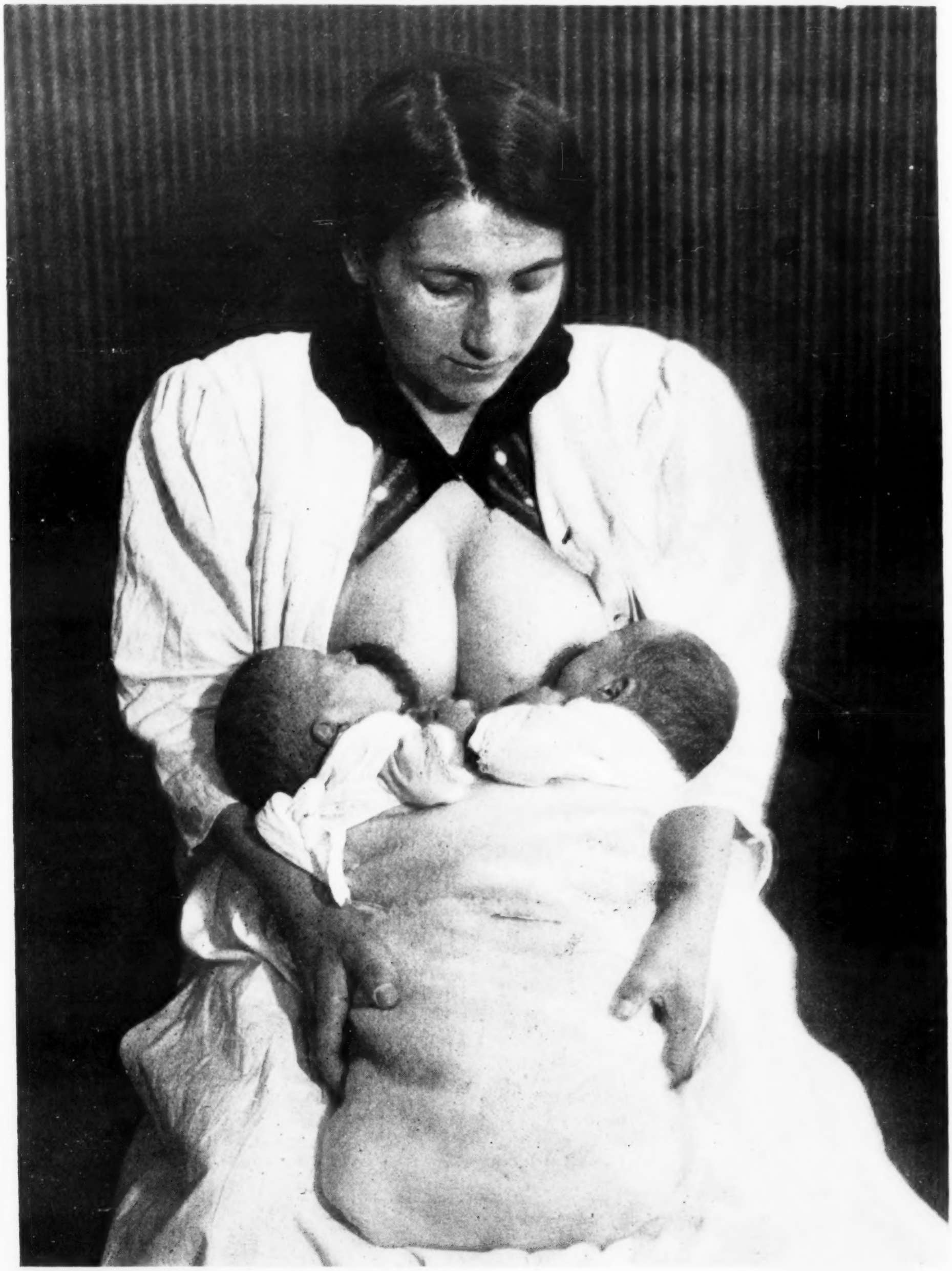
Nebraska Sterilization Law

Sterilization of feebleminded and insane is provided by a law passed by the 1915 session of the Nebraska legislature. It provides that all inmates of state institutions for the feebleminded and insane, the penitentiary, reformatory, industrial home and schools, and other state institutions, who are subject to parole or discharge, shall be examined by a board of five physicians, who shall inquire into the "innate traits, the mental and physical conditions, the personal records, and the family traits and histories." If they find that children of the individual would probably inherit a tendency to feeblemindedness, insanity, or degeneracy, he shall not be given his liberty unless he is sterilized by such an operation as the board of physicians may indicate. The consent of his family and of himself, if possible, must first be obtained.

The Drama in the Service of Eugenics

The "eugenic plays" hitherto presented have been, in general, presentations of negative eugenics and sex-hygiene, and have generally merited the description of unpleasant plays. The Eugenics Section of the Pittsburgh Academy of Science and Art believed that a pleasant play dealing with positive eugenics would be a valuable piece of propaganda. Through its dramatic committee it discovered the value of George Middleton's "The Unborn," and this was recently presented in the Northside Carnegie Lecture Hall. The impression it made was so evident that it is to be repeated on May 2 in another part of the city, and possibly in some other Pennsylvania cities. The performance was made possible by the cooperation of the Little Theater Company, an amateur organization of Pittsburgh. The play, which lasts only twenty minutes and deals with voluntary childlessness, was followed by a spirited discussion.

THE LATEST "SIAMESE TWINS" ON RECORD



Suzanne and Madeleine Durand, born in Paris on November 28, 1913, were joined face to face by a band of hard flesh about a foot in circumference, near the bottom of the breast bone. The two abdominal cavities were in communication through this hollow link, and the small intestines of one girl could be drawn through the link into the other girl by the mere act of breathing, provided one let out her breath while the other drew in hers. The vital organs of the two were complete and separate, however. The twins were separated by Dr. Gustave Le Filliatre on March 4, 1914, and at last reports were growing healthily. The photograph shows them with their nurse, before they had been cut apart. This is said to be the ninth operation of the kind on record. Such twins as these give support to the idea that so-called "identical" twins are the product of a single egg. Photograph from Paul Thompson. (Fig. 3.)

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Prizes for Eugenic Studies

A committee on promotion of the ideal of racial well-being created by the National Council of Education announces that a fund of $1,000 for each of four years has been offered by an anonymous donor. A prize of $100 is open to graduate classes of two-year normal courses in each of four sections of the country. Similarly a prize of $150 to members of graduating classes of colleges and universities in the same sections who have had two years of work in education or home economics. The prize is awarded to the class that makes the best cooperative study on the topic, "The supreme object of education should be to make the next generation better than living generations." The first prizes will be awarded to the class of 1917. Notice of intention to compete should be sent before May 1, 1916, to Dr. H. C. Putnam, Rhode Island Avenue, Providence, R. I., of whom further details can be obtained.—*Eugenical News*.

Defectives in District of Columbia

There are few states which have made less provision for mental defectives than has the Federal Government, and at the present time practically all the feeble-minded, some hundreds in number, in the District of Columbia are allowed at large without any restraint or oversight. Representative Tinkham of Massachusetts has introduced a bill (H. R. 13666) into Congress providing for an institution for the feeble-minded in the District of Columbia, appropriating $500,000 for it and outlining a method of commitment. The measure is receiving the active support of the Committee on Provision for the Feeble-minded (Philadelphia), and deserves the assistance of every one who is interested in proper care for the defective classes in the nation.

Genetics Literature

THE annual reports of the AMERICAN BREEDERS' ASSOCIATION, published in seven volumes, form the most valuable collection of material for students of genetics which has been published in the United States. Most of them are out of print and are becoming very valuable. All of them are nearly indispensable to libraries, institutions and students of plant and animal breeding, heredity, variation, eugenics, or genetics in general.

The Association still has on hand a limited number of copies of three of these reports, which it offers for sale.

Vol. VI, Proceedings A. B. A. (1910), contains 465 pages. Illustrated. It includes 80 papers on general genetic subjects, and among the contributors are practically all the leaders in this study in the United States. **Issued at $2, now offered for $1.**

Vol. VII, Proceedings A. B. A. (1911), and Vol. VIII (1912), bound in one volume of 593 pages, illustrated, and including 73 monographs on the most vital and interesting features of genetics. **Issued at $3, now offered for $1.50.**

The volumes are substantially bound in cloth and will be sent post-paid on receipt of price.

As the Association frequently receives requests for other volumes of the proceedings, which are now out of print, it will be glad to hear from those who have copies for sale or exchange.

In addition to its annual reports, the Association still has on hand a few copies of the following issues of the AMERICAN BREEDERS' MAGAZINE:

Vol. I, Nos. 2 and 4.
Vol. II, Nos. 3 and 4.
Vol. III, No. 2.
Vol. IV, Nos. 1 and 4.

JOURNAL OF HEREDITY:

Vol. V, Nos. 5, 6, 7, 8, 9, 10, 11 and 12.
Vol. VI, Nos. 2, 3, 4, 5, 6, 7, 9, 10, 11 and 12.

Each of these issues contains numerous articles on plant and animal breeding and eugenics, written by specialists and in most cases describing the results of their own researches. In many instances these researches have never been described elsewhere. These numbers will be sold for 25 cents each, post paid.

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THE AMERICAN GENETIC ASSOCIATION

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WHAT GENETICS IS

"An exact determination of the laws of heredity," says William Bateson, "will probably work more change in man's outlook on the world, and in his power over nature, than any other advance in natural knowledge that can be clearly foreseen."

To gain this knowledge is the object of the science of genetics, which proceeds, in practice, largely by means of plant breeding and animal breeding, for the reason that heredity is less complicated in these organisms than in Man, and its operation can be more easily made out. The knowledge so gained finds its application in methods for the improvement of cultivated plants and domesticated animals and, most important of all, in the improvement of the human race through the science of eugenics, which was defined by its founder, Francis Galton, as "the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally."

THE AMERICAN GENETIC ASSOCIATION

is an incorporated organization, co-operative in nature and devoted to promoting knowledge of the laws of heredity in the broadest sense of the word, and their application to the improvement of plants, animals, and human racial stocks. It is the largest organization in the world for the advancement of genetics, and its organ, The Journal of Heredity, is the most important agent for furthering the interchange of ideas between investigators of different phases of these problems, and for the presentation of their results to the public.

Through its committees on research, co-operation with which is not obligatory, but is urged upon every member, the association collects information by means of approved scientific methods applied to the subject of genetics. This information, as well as that derived from other authoritative sources, it endeavors to place before the public by means of its committee on education and extension, and before its membership, in an attractive and understandable way, through this magazine. The association constantly strives to further the cause of conservative, constructive science and to check the progress of fallacious and sensational pseudo-science. While it can not assume responsibility for the accuracy of statements made by contributors to The Journal of Heredity, it endeavors to publish only such as are on a sound scientific basis, and members are urged to contribute such articles, with illustrations. The magazine does not pretend entirely to cover the immense field of genetics, but it is designed to keep members informed of the latest results in research in the most interesting lines, and to present these results in such a way that they will appeal not only to the specialists, but to the general reader who desires to know what the specialists are doing in a science that is of such personal importance to each individual.

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Membership is composed of scientists, teachers, publicists, physicians, clergymen, students, horticulturists, and breeders of live stock, throughout the world. Subject to the approval of the council, any person interested in the improvement of the human race or the creation of better varieties of plants and animals, is eligible for membership. The secretary will be glad to correspond with those interested, and to send a copy of the magazine for examination. Annual dues, giving the right to attend all meetings and to receive the Journal of Heredity, are $2; life membership is $50. Address all communications to

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